BANISTERIA

A JOURNAL DEVOTED TO THE NATURAL HISTORY OF VIRGINIA

Alton McCaleb Harvill, Jr.
(1916-2008)

The foremost authority on the Virginia flora during his career, he was the lead author of three atlases documenting the geographical distribution of plants in the Commonwealth and established a large, regionally significant herbarium at Longwood University.
A memorial tribute to this outstanding botanist appears on pages 89-98 of this issue.

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B A N I S T E R I A

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A Preliminary List of the Leaf-roller Moths (Lepidoptera: Tortricidae) of Virginia

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ABSTRACT

The microlepidopteran fauna of Virginia is poorly documented. We present an annotated checklist of 301 species of leaf-roller moths (Lepidoptera: Tortricidae) recorded from the state based on the examination of 4,207 pinned specimens deposited in institutional or university collections; the specimen database from the Essig Museum of Entomology, University of California, Berkeley (122 specimen records); and literature records. County distribution, capture dates, and host plants are presented for each species. The geographic coverage of the material examined is highly uneven, with most specimens (60%) from Fairfax County (200 species). The poor state of knowledge of the Virginia tortricid fauna is demonstrated by the lack of records for nearly one-fifth of all counties and large independent cities. Much more collecting by both amateur and professional lepidopterists, as well as a review of additional existing collections, is needed before a general understanding of the geographic and temporal distribution of Virginia's tortricid fauna will begin to emerge.

Key words: biodiversity, distribution, faunal survey, host plants, microlepidoptera, phenology.

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INTRODUCTION

Active management of natural lands has become an integral component of efforts focused on the long-term conservation of biological resources, especially those resources occurring in or near fragmented habitat, adjacent to development, or subject to direct and indirect anthropogenic impacts. However, before meaningful management strategies can be developed and implemented, it is essential to identify the constituents of the biodiversity to be conserved. Biotic inventories and faunal surveys represent the first step in that process.

The insect fauna of Virginia has received considerable attention over the last two decades with surveys of groups such as sawflies (Hymenoptera: Symphyta) (Smith, 2006), caddisflies (Trichoptera) (Flint et al., 2004, 2008, 2009), dragonflies and damselflies (Odonata) (e.g., Roble, 1994; Roble et al., 1997), mosquitoes (Diptera: Culicidae) (Harrison et al., 2002), robber flies (Diptera: Asilidae) (Bedell, 2010), true bugs (Heteroptera) (e.g., Hoffman, 1996, 2006), beetles (Coleoptera) (e.g., Anderson et al., 1995; Hoffman & Roble, 2000; Hoffman et al., 2002, 2006, 2009), and butterflies (Lepidoptera: Papilionoidea) (Chazal et al., 2004, 2010a, 2010b). In addition, several "bioblitzes" have provided "snapshot" views of the biota of specific parks (e.g., Evans, 2008). By comparison, the moth fauna of Virginia is poorly documented in the scientific literature. Recently published surveys of macromoths at selected sites in the state include those of Stein (1993), Butler et al. (2001), Steury et al. (2007), and Ludwig (2000, 2001, 2002, 2009). Roble et al. (1999) reported the recent arrival of an exotic noctuid in the state. Likewise, the microlepidopteran (smaller moths) fauna of Virginia remains little studied. There are a few older literature records of tortricids in Virginia such as those reported by Skinner (1921), Heinrich (1923, 1926), and Milne & Milne (1944); more recently, Wagner et al. (1995) reported on larval collections that included 36 species of tortricids. The purpose of this paper is to provide the first list of the tortricid fauna of Virginia as a foundation upon which to build our knowledge of their spatial and temporal distributions.

Tortricid moths (Lepidoptera: Tortricidae), commonly known as leaf-rollers, are one of the largest lineages of microlepidoptera (Kristensen, 1998; Brown, 2005). The common name "leaf-rollers" has been applied to the family owing to the larval habit of shelter-building by folding or rolling leaves of the food plant, but the larvae of tortricids employ a wide variety of feeding strategies, including gall-inducing, stem- and root-boring, fruit-boring, seed-predating, flower-feeding, and leaf litter-feeding; a very few are predaceous on scale insects (Powell et al., 1998; Brown, 2005). Tortricid larvae feed on a wide array of plant families; members of the subfamily Tortricinae usually are polyphagous, whereas those of the subfamily Olethreutinae are more host-specific. Due to their plant-feeding habits, many tortricid species are important pests of agricultural, ornamental, and forest plants. In contrast, some highly localized or rare tortricids may require conservation efforts in order to persist in a changing landscape.

MATERIALS AND METHODS

Study Site

The Commonwealth of Virginia covers 110,784 km^2 and is situated along the mid-Atlantic seaboard of the eastern United States. Politically, the Commonwealth consists of 95 counties and 39 independent cities that are not included within a county; there are five former counties (i.e., no longer recognized as counties) that are now "county-sized" cities.

Virginia is topographically diverse, ranging from sea level along the coast to 1746 m (5729 ft) at Mount Rogers in the Appalachian Mountains, the latter of which form much of the western edge of the state. With five major physiographic provinces recognized within its borders, Virginia encompasses one of the most diverse landscapes in the East (Hoffman, 1969; Woodward & Hoffman, 1991). Its geographic position places it at the southern limit of many northern species and the northern limit of many southern species (DCR, 2009).

Data Sources

We databased specimens of tortricid moths from Lepidoptera collections at the National Museum of Natural History, Smithsonian Institution, Washington, D.C. (USNM), Virginia Polytechnic Institute and State University, Blacksburg (VT), Virginia Museum of Natural History, Martinsville (VMNH), and a sample of specimens from the Essig Museum of Entomology, University of California, Berkeley (EME). We also used the specimen database of the Essig Museum of Entomology (EMDB) for records of tortricids from Virginia. Recent collections made by staff of the Virginia Department of Conservation and Recreation, Division of Natural Heritage throughout the state also were studied, most of which are deposited in the USNM collection. Additional institutional acronyms include the following: AMNH (American Museum of Natural

History, New York, New York); CNC (Canadian National Collection of Insects, Ottawa, Ontario, Canada); FSCA (Florida State Collection of Arthropods, Gainesville, Florida); SNPC (Shenandoah National Park Collection, Luray, Virginia), and VDCR (Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, Virginia).

Each entry (record) in the database represents an individual specimen. The database includes the following fields: subfamily, tribe, genus, species, author, sex, county, locality, latitude, longitude, date(s) collected, collector(s), and additional notes. The database will be made available through the Virginia Department of Conservation and Recreation, Division of Natural Heritage.

We also extracted records of tortricids from several literature sources: Skinner (1921), Heinrich (1923, 1926), Milne & Milne (1944), Powell (1980), Stein (1993), and Wagner et al. (1995). In the Annotated Checklist, all county records are accompanied by their literature citation or the institution where the specimens are deposited.

Nomenclature

Nomenclature follows Brown (2005); tribes are assigned to subfamilies following Horak & Brown (1991) and Brown (2005); and per Horak (2006), Endotheniini is combined with Bactrini. Genera are arranged alphabetically within tribes, as are species within genera. Genera listed in quotes (i.e., "*Cochylis*") indicate that the associated species potentially require a different generic combination (or a new genus), but such has not been formally proposed. Common names are provided in brackets for those species for which one is recognized. A few of the species represent undescribed entities, and these are indicated by "n. sp."

Food Plant Data

Food plant information for each tortricid species was obtained from the database compiled by Brown et al. (2008), where original references for the data can be found. The data include records from throughout the range of each tortricid species, not just their range in Virginia. Family names for plant species follow GRIN (2010). For tortricids recorded from five or fewer hosts, all host species are listed. Where more than five species are recorded, the host plant families are listed followed by the number of host genera recorded for that plant family, e.g., "Asteraceae (6)" indicates that six genera of Asteraceae have been recorded. Host plant families are organized alphabetically.

Spatial Distribution

Specimen records from most independent cities, i.e., those not included within counties, were combined with those of the county that is geographically closest or that physically surrounds the respective city. For example, specimens from the independent cities of Falls Church and Alexandria were combined with those from Fairfax County, and specimens from the City of Richmond were combined with those from Henrico County. However, five of the independent cities are either former counties or encompass large areas; hence, they are treated like counties for purposes of presenting distribution records. These cities and their former county names (included in parentheses) are: City of Chesapeake (formerly Norfolk County; also includes the cities of Norfolk and Portsmouth for the purposes of this paper); City of Hampton (formerly Elizabeth City County); City of Newport News (formerly Warwick County); City of Suffolk (formerly Nansemond County); and City of Virginia Beach (formerly Princess Anne County). In the annotated checklist, county records are listed directly below the species heading; names of these five county-sized cities appear in italics. Specimens labeled only as "Virginia" are included, but detailed distribution data are unknown.

Temporal Distribution

In the annotated checklist, flight period, represented by the earliest and latest date of capture regardless of year, are provided immediately following the list of counties. For species represented by a single specimen, the date of capture of that specimen is given. In a few instances, an additional note is provided to explain the data. The collecting date is not present on the labels of several older specimens, and specific collecting dates are unknown for most of the species mentioned in the literature.

RESULTS AND DISCUSSION

We documented 301 species of Tortricidae from Virginia based on the examination of 4,207 pinned specimens, a review of the Essig Museum specimen database (122 specimen records), and a review of relevant literature. By comparison, Covell (1999) reported 348 species from Kentucky, and Glaser et al. (unpub. data) 319 species from Maryland. Although the documented species richness of tortricids in Virginia is lower than that reported for the adjacent states, based on area and topographic diversity, it is likely that species richness is higher in Virginia. Clearly, much additional sampling is required before a meaningful

estimate of the number of tortricid species in Virginia can be derived.

The number of species and specimens recorded for each county is listed in Table 1. The location and intensity of survey efforts combine to create an uneven and incomplete picture of species distributions for Virginia. Approximately 60% of all specimens examined (2,506 specimens) are from Fairfax County. The disproportionately large number of specimens from this county reflects not only the contemporary collecting efforts of a National Park Service inventory of George Washington Memorial Parkway National Park 2006–2009 (including Turkey Run and Great Falls parks) (n = 515 specimens), a survey by Paul Opler of his residence in Alexandria (Rose Hill) 1975–1977 (n = 638 specimens), and a survey by John Brown of his residence in Fairfax 1997–2010 (n = 541 specimens), but many older specimens collected by Carl Heinrich and August Busck (ca. 1915–1930) are from this county as well. The sampling effort in the rest of Virginia has been much less intensive to nonexistent. In fact, no tortricid has been recorded from 20 (20%) of the 100 current (n = 95) and former (n = 5; now large independent cities) counties (Table 1, Fig. 1). Furthermore, the vast majority of Virginia's counties have fewer than 20 confirmed tortricid species, a figure often obtainable at any single locality in eastern North America. Twenty or more species are recorded from only 13 counties or cities, and 40 or more species are recorded from only six: Giles Co. (n = 40), Bath Co. (n = 41), Rockbridge Co. (n = 43), Montgomery Co. (n = 44), City of Virginia Beach (n = 53), and Fairfax Co. (n = 200). By comparison, George Washington Memorial Parkway National Park alone harbored 61 species, and the Fairfax County residences of Paul Opler and John Brown yielded 85 and 60 species, respectively. Also, Wagner et al. (1995) reported 36 species of tortricids from oaks and blueberry during spring larval sampling at a site in Rockbridge County.

Despite the geographic unevenness of the data, it is readily apparent that some species are widespread in Virginia. Among the most commonly recorded species are *Choristoneura rosaceana* (Harris) (29 counties), *Amorbia humerosana* Clemens (23), *Sparganothis sulfureana* (Clemens) (19), *Cydia latiferreana* (Walsingham) (18), *Ecdytolopha insiticiana* Zeller (18), and *Pandemis limitata* (Robinson) (17). Only 21 species are known from 10 or more counties, further demonstrating the inadequacy of sampling efforts to date. Furthermore, many species have been recorded from only one county (128) or from just one specimen (62). It is premature to attempt to evaluate which of these species actually have narrow distributions or are of potential conservation concern. For example, *Acleris maccana* (Treitschke), *Aethes atomosana* (Busck), *Argyrotaenia juglandana* (Fernald), and *Pseudogalleria inimicella* (Zeller) are represented by one or few Virginia specimens, but they are common to abundant elsewhere. In contrast, *Archips nigriplagana* Franclemont, *Lozotaenia exomilana* Franclemont, *Olethreutes monetiferana* (Riley), and *Pammene perstructana* (Walker), with only single specimens from Virginia, are represented by exceedingly few specimens in the USNM collection in general, and may actually be rare species.

At least nine species documented from Virginia are unidentifiable to species-level and likely represent undescribed species. While some of these belong to poorly studied groups such as Cochylini, others are in genera (e.g., *Pseudexentera*) that have received contemporary revisionary attention (e.g., Miller, 1986; Cho, 1987).

The number of tortricid species in the adult stage (reflected by capture data) is lowest in January, with only a few records of *Acleris* species, many of which overwinter as adults. February records, likewise, are few and dominated by *Acleris* species, but by March a few spring-flying species (e.g., *Pseudexentera*) begin to appear. However, in some years, spring species are not encountered until April. Species richness increases dramatically through May, peaking in late May through early June, and slowly diminishes through mid-September (Fig. 2). Very few species fly as late as November, and December records, again, represent overwintering species of *Acleris*. Although sampling is less than thorough, the data (Appendix 1) confirm previously documented phenological patterns for most species (e.g., Covell, 1999; Gilligan et al., 2008). For example, spring-flying species such as members of the genus *Pseudexentera* were collected only from late March to late May (with one outlying record from mid-July), whereas multivoltine species such as *Clepsis peritana* (Clemens) and *Endothenia hebesana* (Walker) were captured from April through October. Several species show a univoltine fall-flying pattern: *Eucosma dorsisignatana* (Clemens) was captured from mid-August to late October and *Phaneta autumnana* (McDunnough) was captured from late September to early October. The year-round records of *Rhyacionia frustrana* (Scudder) reflect the fact that most of the specimens of this species were laboratory-reared, resulting in unusual times of emergence (i.e., January through late December).

Only seven species are represented by more than 100 specimens: *Clepsis peritana* (Clemens) (n = 302), *Choristoneura rosaceana* (n = 271), *Rhyacionia frustrana* (n = 181), *Argyrotaenia velutinana* (Walker) (n = 176), *Ecdytolopha insiticiana* (n = 139), *Amorbia*

Table 1. Number of species and specimen records by county or county-sized city (based on specimens examined; number of species with an asterisk [*] represents specimens examined plus species from the literature).

County	Species	Specimens	County	Species	Specimens
"Virginia"	25	92	Lancaster	4	4
Accomack	8	14	Lee	7	12
Albemarle	4	20	Loudoun	5	14
Alleghany	8	12	Louisa	0	0
Amelia	0	0	Lunenburg	0	0
Amherst	0	0	Madison	4	12
Appomattox	0	0	Mathews	1	4
Arlington	28	113	Mecklenburg	1	1
Augusta	8	38	Middlesex	1	1
Bath	41*	154	Montgomery	44	96
Bedford	11	42	Nelson	1	1
Bland	2	2	New Kent	5	9
Botetourt	9	11	Northampton	6	14
Brunswick	2	5	Northumberland	9	36
Buchanan	0	0	Nottoway	4	6
Buckingham	0	0	Orange	1	3
Campbell	0	0	Page	16	36
Caroline	29	62	Patrick	13	27
Carroll	2	2	Pittsylvania	0	0
Charles City	1	1	Powhatan	1	1
Charlotte	1	1	Prince Edward	0	0
Chesterfield	17	60	Prince George	4	7
Clarke	1	1	Prince William	20	40
Craig	2	2	Pulaski	3	3
Culpeper	1	1	Rappahannock	0	0
Cumberland	0	0	Richmond	1	1
Dickenson	9	21	Roanoke	6	12
Dinwiddie	3	6	Rockbridge	43*	12
Essex	1	1	Rockingham	18	41
Fairfax	200	2506	Russell	9	13
Fauquier	15	32	Scott	2	2
Floyd	37	81	Shenandoah	1	1
Fluvanna	0	0	Smyth	28	68
Franklin	5	6	Southampton	3	4
Frederick	8	9	Spotsylvania	0	0
Giles	40*	75	Stafford	4	4
Gloucester	0	0	Surry	1	1
Goochland	7	9	Sussex	1	1
Grayson	19	62	Tazewell	3*	2
Greene	1	1	Warren	0	0
Greensville	0	0	Washington	7	11
Halifax	3	5	Westmoreland	3	3
Hanover	34	54	Wise	5	7
Henrico	3	18	Wythe	0	0
Henry	1	1	York	2	2
Highland	9	10	*Chesapeake*	10	30
Isle of Wight	19	55	*Hampton*	4	8
James City	4	5	*Newport News*	0	0
King and Queen	8	25	*Suffolk*	21	63
King George	0	0	*Virginia Beach*	53	329
King William	3	22			

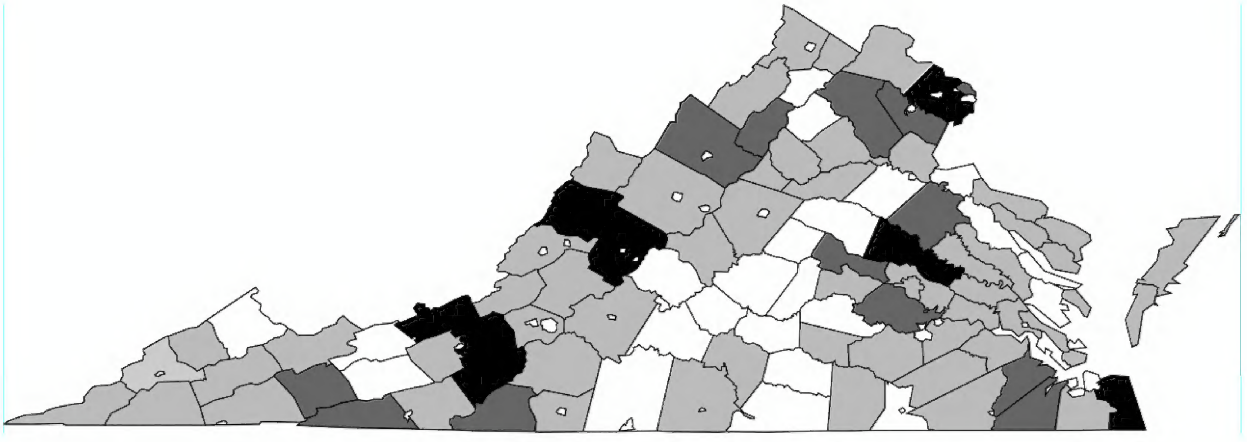

Fig. 1. Counties of Virginia categorized by documented species richness of Tortricidae (based on capture records): white = no recorded species; pale gray = 1–10 species; dark gray = 11–30 species; black = greater than 30 species.

humerosana (n = 121), and *Platynota idaeusalis* (Walker) (n = 117). *Clepsis peritana*, *Choristoneura rosaceana*, *Amorbia humerosana*, and *Platynota idaeusalis* are polyphagous species that occur not only in native habitats, but also are abundant in urban areas, e.g., Alexandria and Fairfax. Furthermore, these species have exceptionally long flight periods, with captures ranging from spring to fall. *Ecdytolopha insiticiana* also occurs in native and urban areas, where it is a pest of black locust (*Robinia pseudoacacia* L.; Fabaceae). However, it has a slightly shorter flight period, from late April to late August. In contrast, the explanation for the abundance of *Rhyacionia frustrana* is quite different. The vast majority of the specimens of this economically important pest species were reared from *Pinus* sp. by Heinrich and others from 1915 to 1929 in Fairfax County. An abundant species for which we have fewer collection records is the host-specific and univoltine *Acleris curvalana* (Kearfott), of which Wagner et al. (1995) recorded more than 600 larvae on blueberry (*Vaccinium vacillans* Torr.; Ericaceae) at their study site in Rockbridge County.

Archipini, the tribe with the greatest number of records (n = 1395), are represented by 10 genera and 37 species, with the majority of records from only four species: *Clepsis peritana* (n = 302), *Choristoneura rosaceana* (n = 271), *Argyrotaenia velutinana* (n = 176), and *A. alisellana* (n = 88). In contrast, Eucosmini, with the second most records (n = 791), are represented by more genera (n = 18) and species (n = 96) than any other tribe. Olethreutini show a relatively high diversity, with 12 genera and 44 species, based on many fewer records (n = 533). On the opposite end of the spectrum, the tribe Euliini is represented by only two species, *Anopina ednana* (Kearfott) and *Eulia ministrana* L. Both of these are northern boreal elements that range south along the Appalachian Mountains as far as the Great Smoky Mountains of Tennessee. *Anopina ednana* has been recorded from British Columbia to Nova Scotia, Canada, south through eastern North America (Maine, Massachusetts, Connecticut, Rhode Island, New York, Pennsylvania, Virginia, and Tennessee). *Eulia ministrana* has a similar distribution but extends south into Oregon in the West. *Apotomops wellingtoniana* (Kearfott), which is expected in Virginia, also ranges from coast to coast in Canada, but occurs as far south as Arizona in the western United States and Tennessee in the East.

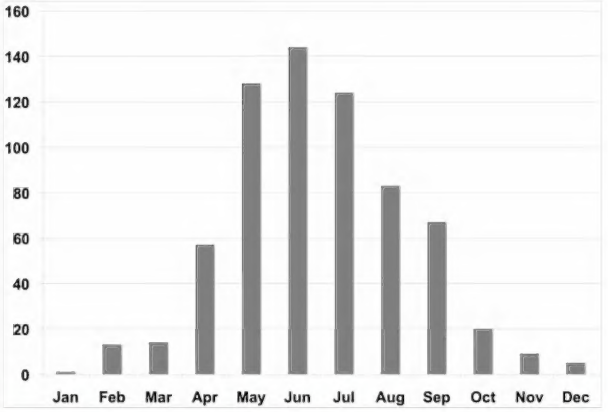

Fig. 2. Tortricid community phenology, i.e., cumulative number of species captured per month.

CONCLUSIONS

Virginia occupies a geographically unique position at the southern end of the range of many northern species, and northern edge of the range of many southern elements. Species such as *Anopina ednana* and *Eulia ministrana* are northern, boreal species that extend south through the Appalachian Mountains to Virginia and Tennessee. *Niasoma metallicana* (Walsingham), *Coelostathma* n. sp., *Sparganothis* (*Cenopis*) *lamberti* Franclemont, and *Platynota rostrana* (Walker) are southern species that reach their northern limits in Virginia or Maryland. Given this unique biogeographic position combined with a moderately diverse topography, one would expect the tortricid fauna of Virginia to exceed that of its surrounding states. However, the documented total number of species is low, indicating considerable undersampling.

Cumulative records from all sources provide uneven geographic and temporal distributions of most tortricid moths within Virginia. Additional sampling is needed in every county of the state; there are no records for one-fifth of Virginia's counties. In contrast, records from Fairfax County provide a relatively thorough inventory of that county. Although incomplete and preliminary, the current inventory represents a foundation upon which a more thorough assessment of the fauna can be built. We anticipate that many more species will be discovered within the Commonwealth. For example, many species documented from Maryland have yet to be found in Virginia, especially those associated with unusual or localized coastal habitats. In addition, the mountainous region along the western edge of the state deserves considerably more attention. Much more collecting by both amateur and professional lepidopterists, as well as a review of additional existing collections, is needed before a general understanding of the geographic and temporal distribution of Virginia's tortricid fauna will begin to emerge.

ANNOTATED CHECKLIST

TORTRICINAE: TORTRICINI

***Acleris cervinana* (Fernald)**
Fairfax (EMDB), Floyd (USNM), Grayson (USNM), Hanover (USMN), Rockingham (USNM).
9 October to 16 April (overwinters as adult).
Host Plants: Betulaceae: *Alnus* sp., *Betula alleghaniensis* Britton, and *Corylus* sp.

***Acleris chalybeana* (Fernald)**
Fairfax (EMDB, USNM), Grayson (USNM), Hanover (USNM).
12 October to 23 April (probably overwinters as adult).
Host Plants: Aceraceae (1), Betulaceae (2), and Fagaceae (2).

***Acleris curvalana* (Kearfott)**
Caroline (USNM), Fairfax (EME, USNM), Giles (USNM), Page (EME), Prince William (USNM), Roanoke (EME), Rockbridge (Wagner et al., 1995).
27 May to 14 July.
Host Plants: Ericaceae (2), Fagaceae (1), and Rosaceae (1).

***Acleris ferrugana* [Denis and Schiffermüller]**
Fairfax (USNM), "Virginia" (USNM).
10 February to 24 May (overwinters as adult).
Host Plants: Betulaceae (2), Fagaceae (2), Rosaceae (3), and Salicaceae (2).

***Acleris flavivittana* (Clemens)**
Fairfax (EMDB, USNM), Floyd (USNM), Hanover (USNM).
27 September to 14 April (overwinters as adult).
Host Plants: Rosaceae: *Malus pumila* Mill. and *Prunus pensylvanica* L.

***Acleris forbesana* (McDunnough)**
Fairfax (EMDB, USNM).
15 December to 25 March (overwinters as adult).
Host Plants: Cornaceae: *Cornus* sp., *C. californica* C. A. Mey, *C. sericea* subsp. *occidentalis* (Torr. & A. Gray) Fosberg, and *C. sericea* subsp. *stolonifera* (Michx.) Fosberg.

***Acleris hastiana* (L.)**
Fairfax (EMDB, USNM).
13 February to 7 April (overwinters as adult).
Host Plants: Betulaceae (1), Ericaceae (3), Fagaceae (1), Myricaceae (1), Rhamnaceae (1), Rosaceae (1), and Salicaceae (2).

***Acleris hudsoniana* (Walker)**
Floyd (USNM).
17 June.
Host Plants: Unknown.

***Acleris kearfottana* (McDunnough)**
Fairfax (EMDB, USNM).
12 November to 13 February (overwinters as adult).
Host Plants: Hamamelidaceae: *Hamamelis* sp. Myrtaceae: *Comptonia peregrina* (L.) and *Myrica gale* L.

***Acleris logiana placidana* (Robinson)**
Caroline (USNM), Fairfax (USNM), Floyd (USNM), Grayson (USNM).
13 October to 21 July (probably overwinters as adult).
Host Plants: Betulaceae (2), Caprifoliaceae (1), and Rosaceae (1).

***Acleris maccana* (Treitschke)**
Rockingham (USNM).
9 October to 24 April (overwinters as adult).
Host Plants: Betulaceae (2), Ericaceae (2), Grossulariaceae (1), Myricaceae (1), Rosaceae (2), and Salicaceae (2).

***Acleris macdunnoughi* Obraztsov**
Smyth (USNM).
2–27 September.
Host Plants: Ericaceae: *Vaccinium* sp. Rosaceae: *Rubus* sp., *Spiraea alba* Du Roi. Salicaceae: *Salix* sp.

***Acleris maculidorsana* (Clemens)**
Caroline (USNM), Chesterfield (USNM), Fairfax (USNM), Hanover (USNM), Rockbridge (Wagner et al., 1995).
12 February to 20 July (probably overwinters as adult).
Host Plants: Clusiaceae: *Hypericum* sp. and *H. perforatum* L. Ericaceae: *Chamaedaphne calyculata* (L.), *Kalmia* sp., and *Vaccinium* sp.

***Acleris minuta* Robinson**
[yellowheaded fireworm]
Isle of Wight (USNM), *Suffolk* (USNM).
10–24 May.
Host Plants: Ericaceae (3), Myricaceae (1), Rosaceae (3), and Salicaceae (1).

***Acleris negundana* (Busck)**
Fairfax (USNM).
28 December to 23 July (overwinters as adult).
Host Plants: Aceraceae: *Acer* sp. and *A. negundo* L.

***Acleris nigrolinea* (Robinson)**
Bath (USNM).
18 August.
Host Plants: Betulaceae (1), Pinaceae (2), Rosaceae (1), and Salicaceae (2).

***Acleris robinsoniana* (Forbes)**
Fairfax (EMDB, USNM).
13 February to 11 July.
Host Plants: Rosacaeae: *Rosa californica* Cham. & Schltdl. Salicaceae: *Populus tremuloides* Michx.

***Acleris schalleriana viburnana* (Clemens)**
Fairfax (EMDB, USNM), Hanover (USNM).
1 October to 8 August (overwinters as adult).
Host Plants: Boraginaceae (1), Caprifoliaceae (1), Ericaceae (1), Rosaceae (2), and Salicaceae (1).

***Acleris semiannula* (Robinson)**
Fairfax (USNM).
17 February (overwinters as adult).
Host Plants: Aceraceae: *Acer* sp., *A. rubrum* L., and *A. saccharinum* L.

***Acleris semipurpurana* (Kearfott)**
[oak leaftier]
Arlington (USNM), Fairfax (EME, USNM), Giles (Milne & Milne, 1944), Isle of Wight (USNM), Montgomery (USNM), Prince William (USNM), Rockbridge (Wagner et al., 1995), Rockingham (USNM), *Virginia Beach* (USNM).
10 May to 23 July.
Host Plants: Fagaceae (1) and Rosaceae (1).

***Acleris simpliciana* (Walsingham)**
Fairfax (EMDB).
29–30 May.
Host Plants: Unknown.

***Acleris subnivana* (Walker)**
Rockbridge (Wagner et al., 1995).
Larval collections.
Host Plants: Asteraceae: *Vernonia* sp. Fagaceae: *Quercus* spp.

***Acleris variana* (Fernald)**
Smyth (USNM).
2 September.
Host Plants: Cupressaceae (1), Pinaceae (6), Salicaceae (1).

***Acleris* n. sp. 1**
Fairfax (USNM).
18 July.
Host Plants: Unknown.

***Acleris* n. sp. 2**
Grayson (USNM).
13 October.
Host Plants: Unknown.

TORTRICINAE: CNEPHASIINI

***Decodes basiplaganus* (Walsingham)**
Bath (USNM), Fairfax (EME, Powell, 1980),

Rockbridge (Wagner et al., 1995).
7–24 September.
Host Plants: Fagaceae: *Quercus* sp. and *Q. lobata* Nee.

TORTRICINAE: ARCHIPINI

***Adoxophyes furcatana* (Walker)**
Bath (USNM), Fairfax (USNM), *Suffolk* (USNM).
21 May to 1 August.
Host Plants: Platanaceae: *Platanus occidentalis* L.

***Archips argyrospila* (Walker)**
[fruittree leafroller]
Fairfax (EMDB), Giles (Milne & Milne, 1944), Rockbridge (Wagner et al., 1995), Rockingham (USNM).
1 June to 13 July (17 July; Milne & Milne, 1944).
Host Plants: Aceraceae (1), Anacardiaceae (2), Betulaceae (1), Caprifoliaceae (1), Cornaceae (1), Ericaceae (5), Fabaceae (5), Fagaceae (1), Grossulariaceae (1), Hydrophyllaceae (1), Juglandaceae (2), Liliaceae (1), Myricaceae (1), Myrtaceae (1), Oleaceae (1), Pinaceae (2), Platanaceae (1), Rhamnaceae (2), Rosaceae (6), Rutaceae (1), Salicaceae (2), Sapindaceae (1), Tiliaceae (1), Ulmaceae (1), and Vitaceae (1).

***Archips cerasivorana* (Fitch)**
[uglynest caterpillar]
Smyth (USNM).
2 July.
Host Plants: Aceraceae (1), Betulaceae (3), Fagaceae (1), Oleaceae (1), Pinaceae (1), Rosaceae (4), Salicaceae (2), and Tiliaceae (1).

***Archips fervidana* (Clemens)**
[oak webworm]
Augusta (USNM), Fairfax (USNM), Floyd (USNM), Giles (Milne & Milne, 1944; USNM), Grayson (USNM), Montgomery (USNM), Page (EMDB), Shenandoah (USNM).
14 June to 10 August.
Host Plants: Fagaceae (1), Juglandaceae (1), Rosaceae (1), and Salicaceae (1).

***Archips grisea* (Robinson)**
Fairfax (EMDB, USNM), Giles (EMDB), Rockbridge (Wagner et al., 1995), Rockingham (USNM), *Suffolk* (USNM).
16 May to 3 July.
Host Plants: Asteraceae: *Rudbeckia* sp. Fagaceae: *Quercus* sp. Juglandaceae: *Carya* sp. Rosaceae: *Pyrus* sp.

***Archips magnoliana* (Fernald)**
Fairfax (EMDB).
3 July.
Host Plants: Magnoliaceae: *Magnolia* sp. and *M. accuminata* L.

***Archips nigriplagana* Franclemont**
Floyd (USNM).
20 June.
Host Plants: Unknown.

***Archips purpurana* (Clemens)**
Bath (Skinner, 1921), Botetourt (USNM), Giles (Milne & Milne, 1944), Montgomery (USNM), Wise (USNM).
15 June to 29 July.
Host Plants: Anacardiaceae (1), Asteraceae (2), Betulaceae (1), Caprifoliaceae (1), Cornaceae (1), Crassulaceae (2), Ericaceae (1), Fagaceae (1), Geraniaceae (1), Grossulariaceae (1), Lauraceae (1), Liliaceae (1), Oleaceae (1), Rosaceae (4), Salicaceae (2), Tiliaceae (1), and Violaceae (1).

***Archips rileyana* (Grote)**
Smyth (USNM).
11–14 July.
Host Plants: Asteraceae (1), Caprifoliaceae (1), Cornaceae (1), Fagaceae (1), Juglandaceae (2), Rosaceae (1), and Sapindaceae (1).

***Archips semiferana* (Walker)**
[oak leafroller]
Fairfax (EMDB), Frederick (USNM), Giles (Milne & Milne, 1944), Page (EMDB), Rockbridge (Wagner et al., 1995).
20 June to 24 July.
Host Plants: Aceraceae (1), Fagaceae (1), Hamamelidaceae (1), Oleaceae (1), Polygonaceae (1), and Rosaceae (1).

***Argyrotaenia alisellana* (Robinson)**
Alleghany (USNM), Bath (Skinner, 1921), Caroline (USNM), Fairfax (USNM), Giles (Milne & Milne, 1944; USNM), Hanover (USNM), Henrico (USNM), Highland (USNM), Isle of Wight (USNM), Montgomery (USNM, VMNH), Prince William (USNM), Rockbridge (Wagner et al., 1995).
16 May to 24 July.
Host Plants: Fagaceae: *Quercus* sp., *Q. alba* L., *Q. macrocarpa* Michx., and *Q. velutina* Lam.

***Argyrotaenia floridana* Obraztsov**
Fairfax (USNM), Lancaster (USNM), *Virginia Beach* (USNM).
1 June to 18 September.

Host Plants: Unknown.

***Argyrotaenia juglandana* (Fernald)**
[hickory leafroller]
Alleghany (USNM), Bath (USNM), Dickenson (USNM), Smyth (USNM).
5 June to 2 September.
Host Plants: Juglandaceae: *Carya cordiformis* (Wangenh.) K. Koch, *C. ovata* (Mill.) K. Koch.

***Argyrotaenia mariana* (Fernald)**
[graybanded leafroller]
Alleghany (USNM), Augusta (USNM), Bath (USNM), Botetourt (USNM), Fairfax (USNM), Fauquier (USNM), Floyd (USNM), Frederick (USNM), Grayson (USNM), Hanover (USNM), Montgomery (USNM), Prince William (USNM), Rockbridge (Wagner et al., 1995), Smyth (USNM).
7 April to 15 July.
Host Plants: Aceraceae (1), Asteraceae (1), Betulaceae (2), Caprifoliaceae (1), Ericaceae (1), Fagaceae (1), Rosaceae (3), Salicaceae (2), and Ulmaceae (1).

***Argyrotaenia occultana* Freeman**
Chesterfield (USNM).
9 April.
Host Plants: Pinaceae (4).

***Argyrotaenia pinatubana* Kearfott**
[pine tube moth]
Bath (USNM), Fairfax (USNM).
20 April to 20 July.
Host Plants: Cupressaceae (1) and Pinaceae (4).

***Argyrotaenia quercifoliana* (Fitch)**
Alleghany (USNM), Arlington (USNM), Bath (USNM), Botetourt (USNM), Dickenson (USNM), Fairfax (EME, USNM), Fauquier (USNM), Giles (Milne & Milne, 1944), Highland (USNM), Lee (USNM), Montgomery (USNM), Roanoke (USNM), Rockbridge (Wagner et al., 1995), Rockingham (USNM), Stafford (USNM), *Suffolk* (USNM), *Virginia Beach* (USNM).
19 May to 12 September.
Host Plants: Aceraceae (1), Anacardicaceae (1), Apocynaceae (1), Fagaceae (1), Hamamelidaceae (1), Rhamnaceae (1), and Rosaceae (2).

***Argyrotaenia tabulana* Freeman**
[jack pine tube moth]
Fairfax (USNM), Patrick (USNM), *Virginia Beach* (USNM).
11– 12 May.
Host Plants: Pinaceae (5).

***Argyrotaenia velutinana* (Walker)**
[redbanded leafroller]
Accomack (USNM), Albemarle (VT), Arlington (USNM), Bedford (USNM), Bland (USNM), Chesterfield (USNM), Fairfax (EME, USNM), Floyd (USNM), Hanover (USNM), James City (USNM), Lancaster (USNM), Middlesex (USNM), Montgomery (USNM, VT), Prince William (USNM), Rockbridge (Wagner et al., 1995), Smyth (USNM), Southampton (USNM), *Suffolk* (USNM), Washington (USNM).
5 March to 8 September.
Host Plants: Aceraceae (1), Apocynaceae (1), Aquifoliaceae (1), Asteraceae (4), Betulaceae (2), Campanulaceae (1), Caprifoliaceae (1), Chenopodiaceae (1), Ericaceae (1), Fagaceae (1), Geraniaceae (1), Malvaceae (1), Myricaceae (1), Orchidaceae (1), Pinaceae (5), Rosaceae (3), Salicaceae (2), Tiliaceae (1), Ulmaceae (1), and Violaceae (1).

***Choristoneura fractivittana* (Clemens)**
Bath (USNM), Chesterfield (USNM), Fairfax (USNM), Fauquier (USNM), Hanover (USNM), Highland (USNM), Isle of Wight (USNM), Montgomery (VT), Rockbridge (Wagner et al., 1995), *Suffolk* (USNM), Tazewell (Stein, 1993), *Virginia Beach* (USNM).
7 May to 4 June.
Host Plants: Aceraceae (1), Betulaceae (1), Fagaceae (2), Rosaceae (2), and Ulmaceae (1).

***Choristoneura fumiferana* (Clemens)**
[spruce budworm]
Fairfax (EMDB), Grayson (USNM), Washington (USNM).
30 June to 2 July.
Host Plants: Balsaminaceae (1), Cupressaceae (2), Pinaceae (6), and Salicaceae (1).

***Choristoneura obsoletana* (Walker)**
Arlington (USNM), Caroline (USNM), *Chesapeake* (USNM), Fairfax (USNM), Fauquier (USNM), Hanover (USNM), Northumberland (EMDB, USNM, VT).
20 May to 6 September.
Host Plants: Annonaceae (1), Betulaceae (1), Ericaceae (2), Fabaceae (1), Rosaceae (3), and Typhaceae (1).

***Choristoneura parallela* (Robinson)**
[spotted fireworm moth]
Accomack (USNM), Essex (USNM), Fairfax (USNM), Floyd (USNM), Halifax (USNM), Hanover (USNM), Lee (USNM), Mecklenburg (USNM), Montgomery (USNM), Prince William (USNM), *Virginia Beach* (USNM), Washington (VT).
7 May to 28 September.

Host Plants: Asteraceae (2), Clusiaceae (1), Ericaceae (3), Fabaceae (1), Myricaceae (1), Rosaceae (1), Rubiaceae (1), Rutaceae (1), Salicaceae (1), Sarraceniaceae (1), and Smilacaceae (1).

***Choristoneura pinus* Freeman**
[jack pine budworm]
Botetourt (USNM), Fairfax (USNM), Floyd (USNM), Montgomery (VT), Roanoke (VT).
4 June to 2 August.
Host Plants: Pinaceae (4).

***Choristoneura rosaceana* (Harris)**
[obliquebanded leafroller]
Bath (Skinner, 1921), Botetourt (USNM), Brunswick (USNM), Caroline (USNM), Chesterfield (USNM), Dinwiddie (USNM), Fairfax (EMDB, EME, USNM), Fauquier (USNM), Frederick (USNM), Giles (Milne & Milne, 1944; USNM), Hanover (USNM, VMNH), Henrico (USNM), Isle of Wight (USNM), King and Queen (USNM), King William (USNM), Lee (USNM), Montgomery (USNM, VMNH), Northampton (USNM), Northumberland (USNM), Nottoway (USNM), Powhatan (USNM), Prince George (USNM), Roanoke (USNM), Rockbridge (Wagner et al., 1995), Rockingham (USNM), Stafford (USNM), *Suffolk* (USNM), Sussex (USNM), *Virginia Beach* (USNM).
11 May to 3 October.
Host Plants: Aceraceae (1), Anacardiaceae (2), Asteraceae (4), Betulaceae (4), Calycanthaceae (1), Caprifoliaceae (3), Caryophyllaceae (1), Clusiaceae (1), Cornaceae (1), Ericaceae (3), Fabaceae (4), Fagaceae (1), Geraniaceae (1), Oleaceae (3), Pinaceae (4), Rhamnaceae (2), Rosaceae (8), Salicaceae (2), Santalaceae (1), Sapindaceae (1), Tiliaceae (1), Ulmaceae (2), and Verbenaceae (1).

***Clepsis clemensiana* (Fernald)**
Floyd (USNM).
July–August.
Host Plants: Apocynaceae (1), Asteraceae (3), Poaceae (1), and Rosaceae (1).

***Clepsis melaleucana* (Walker)**
Augusta (USNM), Bath (USNM), Dickenson (USNM), Fairfax (USNM), Floyd (USNM), Giles (Milne & Milne, 1944; USNM), Grayson (USNM), Hanover (USNM), Patrick (EME), Rockbridge (Wagner et al., 1995), Russell (USNM), Smyth (USNM), Tazewell (USNM).
9 May to 13 July.
Host Plants: Fabaceae: *Trillium grandiflorum* (Michx.) Salisb.

***Clepsis peritana* (Clemens)**
Bath (Skinner, 1921), Bedford (USNM), Caroline (USNM), Chesterfield (USNM), Fairfax (EMDB, EME, USNM), Fauquier (USNM), Floyd (USNM), Giles (Milne & Milne, 1944), Isle of Wight (USNM), Northumberland (USNM), Rockbridge (EME), Rockingham (USNM), Smyth (USNM), *Suffolk* (USNM), *Virginia Beach* (USNM).
4 April to 25 October.
Host Plants: Asteraceae (3), Lamiaceae (1), Polyporaceae (1), Rosaceae (1), Rutaceae (1), Scrophulariaceae (1), and Solacaceae (1).

***Clepsis persicana* (Fitch)**
[green needleworm]
Bath (USNM), Giles (Milne & Milne, 1944), Grayson (USNM), Highland (USNM), Smyth (USNM), Washington (USNM).
14–30 June (8 July; Milne & Milne, 1944).
Host Plants: Aceraceae (1), Apiaceae (1), Asteraceae (1), Betulaceae (3), Cornaceae (1), Ericaceae (1), Gentianaceae (1), Grossulariaceae (1), Liliaceae (1), Myricaceae (1), Oleaceae (1), Pinaceae (5), Rhamnaceae (1), Rosaceae (4), Salicaceae (2), and Ulmaceae (1).

***Clepsis virescana* (Clemens)**
Augusta (USNM), Bath (USNM), Bedford (USNM), Fairfax (USNM), Giles (Milne & Milne, 1944; USNM), Goochland (EME), Grayson (USNM), Montgomery (USNM), Smyth (USNM), Washington (USNM), York (USNM).
17 May to 3 September.
Host Plants: Rosaceae: *Prunus virginiana* var. *demissa* (Nutt.) Torr.

***Cudonigera houstonana* (Grote)**
[juniper budworm]
Accomack (USNM).
2 July.
Host Plants: Cupressaceae: *Juniperus* sp. and *J. californica* Carriere.

***Lozotaenia exomilana* Franclemont**
Giles (USNM).
1 July.
Host Plants: Unknown.

***Pandemis lamprosana* (Robinson)**
Caroline (USNM), Fairfax (USNM), Giles (USNM), Highland (VMNH), Rockbridge (Wagner et al., 1995).
26 May to 4 September.
Host Plants: Aceraceae (1), Betulaceae (2), Fabaceae

(1), Fagaceae (2), Hamamelidaceae (1), Lauraceae (1), Oleaceae (1), Platanaceae (1), Rosaceae (1), Salicaceae (1), Tiliaceae (1), Ulmaceae (1), and Urticaceae (1).

***Pandemis limitata* (Robinson)**
[threelined leafroller]
Bath (USNM), Bedford (USNM), Botetourt (USNM), Chesterfield (USNM), Fairfax (USNM), Floyd (USNM), Hanover (USNM), Highland (USNM), Montgomery (USNM), Northampton (USNM), Patrick (USNM), Prince William (USNM), Rockbridge (Wagner et al., 1995), Rockingham (USNM), Smyth (USNM), *Virginia Beach* (USNM), York (USNM).
25 May to 22 September.
Host Plants: Aceraceae (1), Betulaceae (3), Caprifoliaceae (1), Celastraceae (1), Cornaceae (1), Ericaceae (1), Fabaceae (2), Fagaceae (2), Myricaceae (1), Osmundaceae (1), Rosaceae (3), Salicaceae (2), Tiliaceae (1), and Ulmaceae (1).

***Syndemis afflictana* (Walker)**
Alleghany (USNM), Arlington (EMDB, USNM), Bath (USNM), Fairfax (USNM), Floyd (USNM), Montgomery (USNM, VT), Prince William (USNM), Russell (USNM).
3 April to 20 May.
Host Plants: Betulaceae (2), Cornaceae (1), Myricaceae (1), Pinaceae (4), Rosaceae (1), and Salicaceae (1).

***Xenotemna pallorana* (Robinson)**
Loudoun (VMNH), Montgomery (USNM, VT), Prince William (USNM), Pulaski (USNM).
27 May to 30 August.
Host Plants: Asteraceae (4), Clusiaceae (1), Fabaceae (3), Lamiaceae (1), Pinaceae (2), Rosaceae (3), Santalaceae (1), Ulmaceae (1), and Verbenaceae (1).

TORTRICINAE: SPARGANOTHINI

***Amorbia humerosana* Clemens**
[dusky leafroller]
Arlington (USNM), Augusta (USNM), Bath (USNM), Caroline (USNM), Chesterfield (USNM), Dickenson (USNM), Fairfax (EMDB, USNM), Fauquier (USNM), Floyd (USNM), Hanover (USNM), Isle of Wight (USNM), King and Queen (USNM), Lee (USNM), Montgomery (USNM), Northampton (USNM), Patrick (EMDB, USNM), Prince William (USNM), Russell (USNM), Scott (USNM), Smyth (USNM), *Suffolk* (USNM), *Virginia Beach* (USNM), Wise (USNM).
30 March to 17 July.
Host Plants: Asteraceae (1), Betulaceae (2), Caprifoliaceae (2), Cornaceae (1), Cupressaceae (1), Ericaceae (2), Fagaceae (1), Lauraceae (1), Myricaceae (1), Oleaceae (1), Pinaceae (5), Rosaceae (3), Salicaceae (2), Scrophulariaceae (1), and Ulmaceae (1).

***Coelostathma discopunctana* Clemens**
Bath (USNM), Bedford (USNM), Brunswick (USNM), Chesterfield (USNM), Fairfax (USNM), Goochland (EME), Hanover (USNM), Madison (USNM), Montgomery (USNM), Smyth (USNM), Stafford (USNM).
10 May to 3 September.
Host Plants: Fabaceae: *Desmodium* sp. and *Trifolium* sp.

***Coelostathma* n. sp.**
Caroline (USNM).
26 May.
Host Plants: Unknown.

***Niasoma metallicana* (Walsingham)**
Virginia Beach (USNM).
17 August.
Host Plants: Unknown.

***Platynota exasperatana* (Zeller)**
Chesterfield (USNM), Floyd (USNM), Giles (Milne & Milne, 1944; USNM), Rockbridge (Wagner et al., 1995), *Virginia Beach* (USNM).
11 May to 30 September.
Host Plants: Grasses and detritus (Wagner et al., 1995).

***Platynota flavedana* Clemens**
Albemarle (VT), Augusta (VT), Caroline (USNM), Fairfax (EMDB, FSCA, USNM), Frederick (VT), Isle of Wight (USNM), James City (VT), Loudoun (USNM), Montgomery (VT), Northumberland (VT), Roanoke (VT), *Suffolk* (USNM), *Virginia Beach* (USNM).
6 May to 25 September.
Host Plants: Ericaceae: *Rhododendron* sp. Fabaceae: *Trifolium* sp. Lauraceae: *Sassafras* sp. Rosaceae: *Rosa* sp.

***Platynota idaeusalis* (Walker)**
[tufted apple bud moth]
Arlington (USNM), Bath (Skinner, 1921; USNM), Bedford (USNM), Chesterfield (USNM), Fairfax (EMDB, EME, USNM), Frederick (USNM), Goochland (EME), Grayson (USNM), King and Queen (USNM), Montgomery (USNM), Page (USNM), Patrick (USNM), Prince William (USNM), *Virginia Beach* (USNM), Westmoreland (USNM).
5 May to 24 September.

Host Plants: Asteraceae (1), Betulaceae (1), Caprifoliaceae (1), Cornaceae (1), Oleaceae (1), Pinaceae (1), Ranunculaceae (1), Rosaceae (3), Salicaceae (1), and Vitaceae (1).

***Platynota rostrana* (Walker)**
Virginia Beach (USNM).
1 June to 8 September.
Host Plants: Amaranthaceae (1), Annonaceae (1), Asteraceae (7), Bromeliaceae (1), Caricaceae (1), Caryocaraceae (1), Erythroxylaceae (1), Euphorbiaceae (1), Fabaceae (9), Flacourtiaceae (1), Lauraceae (1), Malpighiaceae (2), Malvaceae (5), Moraceae (1), Myrsinaceae (2), Myrtaceae (2), Ochnaceae (1), Nyctaginaceae (1), Phytolacaceae (1), Pinaceae (1), Rubiaceae (1), Rutaceae (2), Sapotaceae (1), Solanaceae (2), Verbenaceae (2), and Vochysiaceae (2).

***Platynota stultana* Walsingham**
[omnivorous leafroller]
Fairfax (USNM), Montgomery (VMNH)
[apparently introduced in 1933 and again in 1970].
27 April to 20 November (all reared from greenhouse plants).
Host Plants: Amaranthanceae (1), Apiaceae (2), Asteraceae (10), Caryophyllaceae (1), Chenopodiaceae (4), Convolvulaceae (1), Crassulaceae (1), Cupressaceae (1), Fabaceae (14), Ginkgoaceae (1), Juglandaceae (1), Lauraceae (1), Malvaceae (2), Onagraceae (1), Pinaceae (2), Poaceae (1), Polygonaceae (1), Portulaceae (1), Primulaceae (1), Punicaceae (1), Rosaceae (2), Rutaceae (1), Salicaceae (1), Solanaceae (2), Taxaceae (1), Verbenaceae (1), and Vitaceae (1).

***Sparganothis* (*Cenopis*) *albicaudana* Busck**
Rockbridge (Wagner et al., 1995).
Larval collections.
Host Plants: Aceraceae: *Acer* sp. Fagaceae: *Quercus* spp.

***Sparganothis* (*Cenopis*) *cana* (Robinson)**
Virginia Beach (USNM).
10 June.
Host Plants: Unknown.

***Sparganothis* (*Cenopis*) *diluticostana* (Walsingham)**
Fairfax (USNM), Rockbridge (Wagner et al., 1995), *Suffolk* (USNM).
1 June to 3 July.
Host Plants: Apocynaceae (1), Betulaceae (1), Caprifoliaceae (1), Fagaceae (1), Oleaceae (1), and Rosaceae (1).

***Sparganothis* (*Cenopis*) *directana* (Walker)**
[chokecherry leafroller]
Dinwiddie (USNM), Page (CNC, EME), Prince Willam (USNM), Rockbridge (Wagner et al., 1995), *Virginia Beach* (USNM), Wise (USNM).
10 June to 4 August.
Host Plants: Betulaceae (1), Ericaceae (1), Fabaceae (1), Fagaceae (1), Juglandaceae (1), Pinaceae (1), and Rosaceae (1).

***Sparganothis* (*Cenopis*) *lamberti* Franclemont**
Isle of Wight (USNM), New Kent (USNM), *Suffolk* (USNM), *Virginia Beach* (USNM).
17 June to 28 August.
Host Plants: Unknown.

***Sparganothis* (*Cenopis*) *pettitana* (Robinson)**
Chesapeake (USNM), Montgomery (USNM), Rockbridge (Wagner et al., 1995), *Suffolk* (USNM).
16 May to 30 June.
Host Plants: Aceraceae (1), Betulaceae (4), Fagaceae (1), Juglandaceae (1), Rosaceae (1), Salicaceae (1), Tiliaceae (1), and Ulmaceae (1).

***Sparganothis* (*Cenopis*) *reticulatana* (Clemens)**
Bath (Skinner, 1921), Bedford (USNM), Caroline (USNM), *Chesapeake* (USNM), Chesterfield (USNM), Fairfax (EME, USNM), Fauquier (USNM), Floyd (USNM), Greene (USNM), Hanover (USNM), Highland (USNM), Prince William (USNM), Rockbridge (Wagner et al., 1995), *Virginia Beach* (USNM).
26 May to 3 September.
Host Plants: Aceraceae (1), Aquifoliaceae (1), Asteraceae (1), Betulaceae (3), Caprifoliaceae (1), Chenopodiaceae (1), Dryopteridaceae (1), Ebenaceae (1), Ericaceae (1), Fagaceae (2), Geraniaceae (1), Moraceae (1), Myricaceae (1), Oleaceae (1), Orchidaceae (1), Rosaceae (5), Salicaceae (1), and Vitaceae (1).

***Sparganothis* (*Cenopis*) *saracana* (Kearfott)**
Page (EME).
24 July.
Host Plants: Lauraceae: *Sassafras* sp.

***Sparganothis* (*Cenopis*) n. sp.**
Wise (USNM).
1 July.
Host Plants: Unknown.

***Sparganothis* (*Sparganothis*) *bistriata* Kearfott**
Virginia Beach (USNM).
5 July to 8 September.

Host Plants: Unknown.

***Sparganothis* (*Sparganothis*) *distincta* (Walsingham)**
Fairfax (USNM), Hanover (USNM), Northumberland (USNM).
10 June to 27 August.
Host Plants: Asteraceae: *Solidago* sp. and *S. sempervirens* L.

***Sparganothis* (*Sparganothis*) *sulfureana* (Clemens) [sulfur leafroller]**
Accomack (USNM), Arlington (USNM), Bath (Skinner, 1921), Botetourt (USNM), Caroline (USNM), *Chesapeake* (USNM), Fairfax (EMDB, USNM), Fauquier (USNM), Floyd (USNM), Frederick (USNM), Giles (Milne & Milne, 1944; USNM), Isle of Wight (USNM), James City (USNM), Lancaster (USNM), Loudoun (USNM), Montgomery (AMNH, USNM, VMNH, VT), Rockingham (USNM), *Suffolk* (USNM), *Virginia Beach* (USNM).
26 May to 9 October.
Host Plants: Apiaceae (2), Asteraceae (6), Clusiaceae (1), Cupressaceae (1), Ericaceae (1), Fabaceae (5), Lamiaceae (2), Liliaceae (1), Onagraceae (1), Pinaceae (4), Poaceae (1), Ranunculaceae (1), Rosaceae (4), Rutaceae (1), Salicaceae (1), Santalaceae (1), Scrophulariaceae (1), Ulmaceae (1), Verbenaceae (1), and Vitaceae (1).

***Sparganothis* (*Sparganothis*) *tristriata* Kearfott**
Montgomery (USNM).
31 August.
Host Plants: Cupressaceae (1), Pinaceae (4), Rosaceae (2), and Saliaceae (1).

***Sparganothis* (*Sparganothis*) *unifasciana* (Clemens)**
Alleghany (USNM), Highland (USNM), Montgomery (USNM), Pulaski (USNM), Rockbridge (Wagner et al., 1995).
8 June to 30 July.
Host Plants: Asteraceae (1), Ericaceae (1), Fabaceae (1), Fagaceae (1), Oleaceae (1), Pinaceae (2), Ranunculaceae (2), and Rosaceae (5).

***Sparganothis* (*Sparganothis*) *violaceana* (Robinson)**
Giles (USNM).
14–21 June.
Host Plants: Unknown.

***Sparganothis* (*Sparganothis*) *xanthoides* (Walker)**
Floyd (USNM), Franklin (USNM), Giles (Milne & Milne, 1944), Hanover (USNM), Montgomery (USNM), Page (CNC, EMDB), Smyth (USNM).
20 June to 8 August.
Host Plants: Rosaceae: *Holodiscus discolor* (Pursh) Maxim.

***Sparganothoides lentiginosana* (Walsingham)**
Fairfax (EME, USNM), *Virginia Beach* (USNM).
10 June to 5 October.
Host Plants: Asteraceae: *Achillea millefolium* L. (in the laboratory).

TORTRICINAE: EULIINI

***Anopina ednana* (Kearfott)**
Giles (USNM), Madison (USNM).
3 July to 12 August.
Host Plants: Betulaceae: *Betula populifolia* Marshall.

***Eulia ministrana* L.**
Grayson (USNM, VDCR), Page (SNPC).
2–6 June (May to June elsewhere).
Host Plants: Betulaceae (3), Caprifoliaceae (1), Ericaceae (1), Fagaceae (2), Oleaceae (1), Onagraceae (1), Rhamnaceae (2), Rosaceae (4), Salicaceae (1), and Tiliaceae (1).

TORTRICINAE: COCHYLINI

***Aethes angustana* (Clemens)**
Bedford (USNM), Fairfax (USNM), Grayson (USNM), Stafford (USNM).
31 May to 13 October.
Host Plants: Unknown; possibly Asteraceae.

***Aethes argentilimitana* (Robinson)**
Caroline (USNM), Fairfax (USNM).
20 May to 4 September.
Host Plants: Unknown; possibly Asteraceae.

***Aethes atomosana* (Busck)**
Floyd (USNM).
12 September.
Host Plants: Unknown; possibly Asteraceae.

***Aethes floccosana* (Walker)**
Smyth (USNM).
30 June.
Host Plants: Unknown; possibly Asteraceae.

***Aethes interruptofasciata* (Robinson)**
Fairfax (USNM).
28–31 May.
Host Plants: Unknown; possibly Asteraceae.

***Aethes promptana* (Robinson)**
Fairfax (USNM).
2 September.
Host Plants: Unknown; possibly Asteraceae.

***Aethes sexdentata* Sabourin & Miller**
Fairfax (USNM).
30 June.
Host Plants: Unknown; possibly Asteraceae.

***Aethes* n. sp. 1**
Fairfax (USNM), Franklin (USNM).
30 June to 23 August.
Host Plants: Unknown; possibly Asteraceae.

***Aethes* n. sp. 2**
Bedford (USNM), Fairfax (USNM).
26 May to 20 August.
Host Plants: Unknown; possibly Asteraceae.

***Carolella bimaculnaa* (Robinson)**
Fairfax (USNM).
4 September.
Host Plants: Unknown.

***Carolella sartana* (Hübner)**
Caroline (USNM), Hanover (USNM), Isle of Wight (USNM), Prince George (USNM).
14 June to 8 August.
Host Plants: Unknown.

***"Cochylis" aurorana* (Kearfott)**
Fairfax (USNM).
8 September.
Host Plants: Unknown.

***"Cochylis" hoffmanana* (Kearfott)**
Bland (USNM), Craig (USNM), Fairfax (USNM).
16 April to 13 August.
Host Plants: Asteraceae: *Symphyotrichum novae-angeliae* (L.) G. L. Nesom.

***"Cochylis" oenotherana* (Riley)**
Virginia Beach (USNM).
7 September.
Host Plants: Onagraceae: *Oenothera* sp.

***"Cochylis" temerana* (Busck)**
Fairfax (EMDB, USNM).
15–18 April.
Host Plants: Unknown.

***Henricus contrastana* (Kearfott)**
Fairfax (USNM), *Virginia Beach* (USNM).
9–13 June.
Host Plants: Cupressaceae: *Juniperus* sp. Fagaceae: *Quercus lobata*.

***Phalonidia lepidana* (Clemens)**
Fairfax (USNM).
28 May.
Host Plants: Unknown.

***Phtheochroa riscana* (Kearfott)**
Fairfax (USNM), Floyd (USNM).
13 June to 30 August.
Host Plants: Probably Asteraceae.

***Phtheochroa terminana* (Busck)**
Alleghany (USNM), Bath (USNM), Bedford (USNM), Carroll (USNM), Fauquier (USNM), Floyd (USNM), Lee (USNM), Montgomery (USNM), Prince William (USNM), Russell (USNM), Scott (USNM).
8 June to 16 September.
Host Plants: Asteraceae: *Verbasina alternifolia* (L.) Britton ex Kearney.

***Platphalonidia* nr. *felix* (Walsingham)**
Fairfax (USNM).
24 July to 21 August.
Host Plants: Asteraceae: *Senecio blochmaniae* E. Greene and *S. douglasii* DC.

***Rudenia leguminana* (Busck)**
Fairfax (USNM).
3 May to 28 August.
Host Plants: Fabaceae (7).

***Thyraylia* n. sp.**
Fairfax (USNM).
Collecting dates illegible.
Host Plants: Unknown.

OLETHREUTINAE: BACTRINI

***Bactra furfurana* (Haworth)**
Fairfax (USNM, EMDB).
11 June to 30 August.
Host Plants: Cyperaceae (2) and Juncaceae (1).

***Bactra maiorina* Heinrich**
Arlington (USNM), Fairfax (USNM).
9 June.
Host Plants: Cyperaceae: *Bolboschoenus fluviatilis* (Torr.) Sojak and *Scirpus* sp.

***Bactra verutana* Zeller**
Fairfax (USNM), *Virginia Beach* (USNM).
11 June to 9 November.
Host Plants: Cyperaceae (2) and Juncaceae (1).

***Endothenia hebesana* (Walker)**
[verbena bud moth]
Bath (Skinner, 1921; USNM), Caroline (USNM), *Chesapeake* (USNM), Fairfax (USNM), Floyd (USNM), Giles (Milne & Milne, 1944), Hanover (USNM), Montgomery (USNM), Page (EMDB), Patrick (USNM), Smyth (USNM), *Virginia Beach* (USNM).
19 April to 24 September.
Host Plants: Asteraceae (1), Anacardiaceae (1), Betulaceae (1), Gentianaceae (1), Iridaceae (1), Lamiaceae (3), Ranunculaceae (1), Sarraceniaceae (1), Scrophulariaceae (7), and Verbenaceae (1).

***Endothenia montanana* (Kearfott)**
Fairfax (EME).
27–28 June.
Host Plants: Lamiaceae: *Stachys* sp.

***Endothenia nubilana* (Clemens)**
Fairfax (EME, USNM).
23 August to 21 September.
Host Plants: Boraginaceae: *Symphytum* sp. Lamiaceae: *Menthas* sp., *Stachys* sp., and *Teucrium canadense* L.

***Hulda impudens* (Walsingham)**
Bath (USNM), Fairfax (EMDB, USNM), Giles (Milne & Milne, 1944; USNM), Grayson (USNM), Madison (USNM), Rockingham (USNM), Smyth (USNM), *Suffolk* (USNM).
30 May to 2 September.
Host Plants: Unknown.

OLETHREUTINAE: OLETHREUTINI

***Celypha cespitana* (Hübner)**
Fairfax (EME, USNM), Rockbridge (EME), Rockingham (USNM), *Suffolk* (USNM).
15 May to 23 September.
Host Plants: Ericaceae (1), Fabaceae (2), Fagaceae (1), Lamiaceae (1), Pinaceae (1), Plumbaginaceae (2), Poaceae (1), Rosaceae (1), and Salicaceae (1).

***Episimus argutanus* (Clemens)**
Arlington (USNM), Fairfax (EMDB, USNM), Giles (Milne & Milne, 1944), Rockbridge (USNM), Westmoreland (USNM).
22 May to 21 September.
Host Plants: Anacardiaceae (2), Asteraceae (2), Betulaceae (1), Caprifoliaceae (1), Cornaceae (1), Ericaceae (1), Euphorbiaceae (1), Hamamelidaceae (1), Rosaceae (1), and Ulmaceae (1).

***Episimus tyrius* Heinrich**
Fairfax (EME, USNM), *Virginia Beach* (USNM).
26 May to 27 July.
Host Plants: Aceraceae (1), Aquifoliaceae (1), Magnoliaceae (1), Myricaceae (1), Rosaceae (1), and Theaceae (1).

***Eumarozia malachitana* (Zeller)**
Chesterfield (USNM), Fairfax (EME, USNM), Goochland (EME), Northampton (USNM), Northumberland (USNM), *Virginia Beach* (USNM).
29 June to 7 October.
Host Plants: Amaranthaceae (1), Betulaceae (1), Cornaceae (1), Ebenaceae (1), Fabaceae (1), and Rosaceae (1).

***Hedya chionosema* (Zeller)**
[twinspotted budworm]
Fairfax (USNM), Floyd (USNM), Frederick (USNM).
30 April to 1 July.
Host Plants: Fagaceae (1) and Rosaceae (5).

***Hedya cyanana* (Murtfeldt)**
Chesapeake (USNM), Fairfax (USNM), *Hampton* (USNM), King and Queen (USNM).
16 May to 11 August.
Host Plants: Asteraceae: *Cirsium* sp.

***Hedya ochroleucana* (Frölich)**
Fairfax (USNM).
29 June.
Host Plants: Rosaceae: *Malus* sp., *Pyrus communis* L., *Rosa* sp., and *Sorbus* sp.

***Metendothenia separatana* (Kearfott)**
Virginia Beach (USNM).
3 August.
Host Plants: Betulaceae (1), Ranunculaceae (1), and Rosaceae (4).

***Olethreutes appendiceum* (Zeller)**
Fairfax (EME), Rockbridge (Wagner et al., 1995), Rockingham (USNM), Russell (USNM), *Virginia Beach* (USNM).
23 May to 17 July.
Host Plants: Aceraceae (1), Anacardiaceae (1), Betulaceae (3), Ericaceae (1), Fagaceae (2), Grossulariaceae (1), Rosaceae (2), and Salicaceae (2).

***Olethreutes astrologana* (Zeller)**
Fairfax (EME, USNM), Rockbridge (EMDB), Smyth (USNM).
30 May to 30 June.
Host Plants: Unknown.

***Olethreutes atrodentana* (Fernald)**
Rockbridge (Wagner et al., 1995).
Larval collections.
Host Plants: Fagaceae: *Quercus* spp.

***Olethreutes auricapitana* (Walsingham)**
Fairfax (USNM).
12 June.
Host Plants: Betulaceae: *Betula* sp. and *B. alleghaniensis* Britton. Dryopteridaceae: *Matteuccia struthiopteris* (L.) Tod.

***Olethreutes bipartitana* (Clemens)**
Bath (USNM), Highland (USNM).
18 May to 11 August.
Host Plants: Apiaceae: *Apium graveolens* L. and *Spermolepis* sp.

***Olethreutes brunneopurpurata* (Heinrich)**
Caroline (USNM), Fairfax (USNM).
20 July.
Host Plants: Betulaceae: *Alnus* sp.

***Olethreutes concinnana* (Clemens)**
Fairfax (USNM), Floyd (USNM).
3 June to 21 July.
Host Plants: Rosaceae: *Rubus* sp.

***Olethreutes coruscana* (Clemens)**
Arlington (USNM), Fairfax (EME, USNM), Isle of Wight (USNM), Montgomery (USNM), Rockbridge (EME).
7 May to 30 June.
Host Plants: Unknown.

***Olethreutes corylana* (Fernald)**
Nottoway (USNM).
16 May.
Host Plants: Betulaceae: *Corylus* sp. and *C. americana* Marshall.

***Olethreutes fasciatana* (Clemens)**
Arlington (USNM), Bath (USNM), Dickenson (USNM), Fairfax (EMDB, USNM), Giles (USNM), Highland (USNM), Page (EME), Prince William (USNM), Rockingham (USNM), Smyth (USNM), *Suffolk* (USNM), *Virginia Beach* (USNM).
25 May to 23 July.
Host Plants: Salicaceae: *Populus* sp., *P. balsamifera* L., *P. tremuloides* Michx., and *Salix* sp.

***Olethreutes ferriferana* (Walker)**
Arlington (USNM), Fairfax (USNM).
25 May to 12 June.
Host Plants: Hydrangaceae: *Hydrangea* sp.

***Olethreutes ferrolineana* (Walker)**
Franklin (USNM), Highland (USNM), Montgomery (VT).
27 May to 6 June.
Host Plants: Unknown.

***Olethreutes footiana* (Fernald)**
Halifax (USNM).
26 June (emergence date).
Host Plants: Fagaceae: *Quercus* sp. Hamamelidaceae: *Hamamelis* sp. and *H. virginiana* L.

***Olethreutes glaciana* (Möschler)**
Highland (USNM).
6 June.
Host Plants: Aceraceae (1), Betulaceae (1), Rosaceae (1), and Salicaceae (2).

***Olethreutes griseoalbana* (Walsingham)**
Fairfax (USNM), *Virginia Beach* (USNM).
1 June to 16 September.
Host Plants: Unknown.

***Olethreutes hamameliana* (McDunnough)**
Fauquier (USNM), Montgomery (USNM), Russell (USNM).
23 May to 10 June.
Host Plants: Hamamelidaceae: *Hamamelis* sp. and *H. virginiana* L.

***Olethreutes inornatana* (Clemens)**
Arlington (USNM), Bath (Skinner, 1921), Clarke (USNM), Culpeper (USNM), Hanover (USNM), Smyth (USNM).
7 July to 18 August.
Host Plants: Clethraceae (1), Cornaceae (1), Fagaceae (1), Juglandaceae (1), and Rosaceae (1).

***Olethreutes lacunana* (Freeman)**
Rockbridge (Wagner et al., 1995).
Larval collections.
Host Plants: Ericaceae: *Vaccinium* sp.

***Olethreutes merrickanum* (Kearfott)**
Page (USNM).
6 July.
Host Plants: Betulaceae: *Ostrya* sp. and *O. virginiana*

(Mill.) K. Koch. Juglandaceae: *Carya* sp.

***Olethreutes monetiferana* (Riley)**
Lee (USNM).
25 May.
Host Plants: Sapindaceae: *Aesculus flava* Willd.

***Olethreutes nitidana* (Clemens)**
Floyd (USNM).
5 July.
Host Plants: Aceraceae: *Acer* sp.

***Olethreutes olivaceana* (Fernald)**
Fairfax (USNM), Grayson (USNM).
29 May to 4 September.
Host Plants: Betulaceae: *Corylus* sp. Rosaceae: *Fragaria* sp.

***Olethreutes osmundana* (Fernald)**
Caroline (USNM).
20 July.
Host Plants: Asteraceae: *Ambrosia trifida* L. Osmundaceae: *Osmunda cinnamomea* L. and *O. regalis* L. Polypodiaceae: *Pteridium aquilinum* (L.) Kuhn.

***Olethreutes permundana* (Clemens)**
Fairfax (USNM), Page (EME), Rockingham (USNM), *Suffolk* (USNM).
1 June to 8 August.
Host Plants: Anacardiaceae (1), Betulaceae (1), Ericaceae (1), Jugladaceae (1), Myricaceae (1), and Rosaceae (4).

***Olethreutes troglodana* (McDunnough)**
Dickenson (USNM), Fairfax (USNM).
4–13 June.
Host Plants: Unknown.

***Orthotaenia undulana* [Denis and Schiffermüller]**
Giles (USNM).
14–21 June.
Host Plants: Aceraceae (1), Asteraceae (1), Betulaceae (2), Caprifoliaceae (1), Chenopodiaceae (1), Cornaceae (1), Ericaceae (1), Fagaceae (1), Grossulariaceae (1), Lamiaceae (2), Myricaceae (1), Oleaceae (1), Onagraceae (1), Pinaceae (1), Rosaceae (4), Salicaeae (1), and Urticaceae (1).

***Paralobesia liriodendrana* (Kearfott)**
Fairfax (EME, USNM), Floyd (USNM), Patrick (USNM).
17 May to 26 August.
Host Plants: Magnoliaceae: *Liriodendron tulipifera* L., *Magnolia* sp., *M. grandiflora* L., and *M. virginiana* L.

***Paralobesia piceana* (Freeman)**
Fairfax (USNM).
3 September.
Host Plants: Pinaceae (5).

***Paralobesia rhoifructana* (Kearfott)**
Fairfax (USNM).
7 July to 1 August.
Host Plants: Anacardiaceae (1), Asteraceae (1), Cornaceae (1), and Ericaceae (1).

***Paralobesia spiraeifoliana* (Heinrich)**
Fairfax (USNM).
18 April to 28 May.
Host Plants: Rosaceae: *Spiraea salicifolia* L.

***Paralobesia viteana* (Clemens)**
[grape berry moth]
Fairfax (USNM), Nelson (USNM).
26 May to 13 June.
Host Plants: Fabaceae (1), Lauraceae (1), Rosaceae (1), and Vitaceae (1).

***Paralobesia yaracana* (Kearfott)**
Fairfax (USNM).
13 June to 23 July.
Host Plants: Unknown.

***Phaecasiophora confixana* (Walker)**
Caroline (USNM), Dickenson (USNM), Fairfax (USNM), Fauquier (UNM), Prince George (USNM), *Suffolk* (USNM).
20 May to 8 August.
Host Plants: Unknown.

***Phaecasiophora niveiguttana* Grote**
Bath (USNM), *Chesapeake* (USNM), Fairfax (EME, USNM), Fauquier (USNM), Goochland (EME), Hanover (USNM), Isle of Wight (USNM), King and Queen (USNM), Page (EME), Patrick (EME), *Suffolk* (USNM), *Virginia Beach* (USNM).
20 May to 21 August.
Host Plants: Hamamelidaceae: *Hamamelis* sp. and *H. virginiana* L. Lauraceae: *Sassafras* sp. and *S. albidum* (Nutt.) Nees.

***Pristerognatha agilana* (Clemens)**
Fairfax (USNM), Highland (USNM).
18–28 May.
Host Plants: Balsaminaceae: *Impatiens* sp. and *I. capensis* Meerb.

***Zomaria interruptolineana* (Fernald)**
Fairfax (USNM), New Kent (USNM), Patrick (USNM),

Virginia Beach (USNM).
21 April to 7 September.
Host Plants: Ericaceae (4) and Sapotaceae (1).

OLETHREUTINAE: ENARMONIINI

***Ancylis burgessiana* (Zeller)**
Bath (USNM), Fairfax (USNM).
18 May.
Host Plants: Betulaceae (1), Fagaceae (3), and Rosaceae (2).

***Ancylis carbonana* Heinrich**
Giles (USNM).
14 June.
Host Plants: Unknown.

***Ancylis comptana* (Frölich)**
[strawberry leafroller]
Arlington (USNM), Fairfax (USNM), New Kent (USNM).
28 April to 3 August.
Host Plants: Asteraceae (1), Ericaceae (1), Lamiaceae (2), and Rosaceae (7).

***Ancylis discigerana* (Walker)**
Giles (USNM), Smyth (USNM).
23 May to 14 June.
Host Plants: Betulaceae: *Betula alleghaniensis* Britton and *B. papyrifera* Marshall. Salicaceae: *Populus tremuloides* Michx.

***Ancylis divisana* (Walker)**
Fairfax (USNM), Goochland (EME), Rockbridge (Wagner et al., 1995).
28 May to 5 September.
Host Plants: Betulaceae: *Carpinus* sp. Fagaceae: *Castanea dentata* (Marshall) Borkh. Platanaceae: *Platanus* sp. and *P. occidentalis* L.

***Ancylis fuscociliana* (Clemens)**
Giles (USNM).
14 June.
Host Plants: Unknown.

***Ancylis geminana* (Donovan)**
Grayson (USNM).
2 May.
Host Plants: Salicaceae: *Salix* sp., *S. atrocinerea* Brot., *S. aurita* L., and *S. repens* L.

***Ancylis goodelliana* (Fernald)**
Giles (USNM).
14 June.
Host Plants: Unknown.

***Ancylis laciniana* (Zeller)**
Chesterfield (USNM), Fairfax (USNM), Giles (Milne & Milne, 1944; USNM).
11 May to 14 June (21 July; Milne & Milne, 1944).
Host Plants: Betulaceae: *Ostrya virginiana* (Mill.) K. Koch. Fagaceae: *Quercus alba* L.

***Ancylis metamelana* (Walker)**
Fairfax (EMDB, USNM).
8 May to 21 September.
Host Plants: Fabaceae: *Trifolium hybridium* L., *T. pratense* L., and *T. repens* L.

***Ancylis muricana* (Walsingham)**
Fairfax (USNM).
20 May to 21 July.
Host Plants: Betulaceae: *Betula* sp. Cornaceae: *Cornus* sp. and *C. racemosa* Lam. Rosaceae: *Fragaria* sp. and *Rubus* sp.

***Ancylis nubeculana* (Clemens)**
Augusta (USNM), Grayson (USNM).
2–25 May.
Host Plants: Rosaceae (5).

***Ancylis platanana* (Clemens)**
Bath (USNM), Carroll (USNM), Fairfax (EMDB, USNM).
23 April to 12 September.
Host Plants: Platanaceae: *Platanus* sp. and *P. occidentalis* L.

***Ancylis semiovana* (Zeller)**
Fairfax (USNM).
17 June.
Host Plants: Rhamnaceae: *Cayoides crispum* (L.), *Ceanothus* sp., and *C. americana* L.

***Ancylis subaequana* (Zeller)**
Giles (USNM).
14 June.
Host Plants: Unknown.

OLETHREUTINAE: EUCOSMINI

***Catastega aceriella* Clemens**
[maple trumpet skeletonizer]
Fairfax (EMDB, EME, USNM).
14 June to 2 July.

Host Plants: Aceraceae (1), Fagaceae (1), and Rosaceae (1).

***Catastega timidella* Clemens**
Patrick (EMDB).
3 June.
Host Plants: Betulaceae (1), Fagaceae (1), and Juglandaceae (1).

***Chimoptesis gerulae* (Heinrich)**
Fairfax (USNM).
27 February.
Host Plants: Unknown.

***Chimoptesis pennsylvaniana* (Kearfott)**
Rockbridge (Wagner et al., 1995).
Larval collections.
Host Plants: Fagaceae: *Quercus* spp.

***Epiblema boxcana* (Kearfott)**
Fairfax (USNM).
15 May.
Host Plants: Unknown.

***Epiblema brightonana* (Kearfott)**
Fairfax (EME), Grayson (USNM), Hanover (USNM), Montgomery (USNM).
10 June to 7 August.
Host Plants: Unknown.

***Epiblema carolinana* (Walsingham)**
Fairfax (USNM), Lee (USNM), Patrick (USNM).
21–24 August.
Host Plants: Asteraceae: *Rudbeckia* sp. and *R. laciniata* L.

***Epiblema desertana* (Zeller)**
Fairfax (USNM).
16 April to 27 June.
Host Plants: Asteraceae: *Euthamia graminifolia* (L.) Nutt. and *Solidago* sp.

***Epiblema infelix* Heinrich**
Giles (USNM).
14–21 June.
Host Plants: Probably Asteraceae.

***Epiblema numerosana* (Zeller)**
Fairfax (USNM).
7 July.
Host Plants: Probably Asteraceae.

***Epiblema obfuscana* (Dyar)**
Rockbridge (EME).
2 June.
Host Plants: Asteraceae: *Solidago* sp.

***Epiblema otiosana* (Clemens)**
[bidens borer]
Fairfax (EMDB, USNM), Hanover (USNM), New Kent (USNM) *Suffolk* (USNM), *Virginia Beach* (USNM), Westmoreland (USNM).
24 May to 29 August.
Host Plants: Asteraceae: *Ambrosia* sp., *Bidens* sp., *B. cernua* L., and *B. frondosa* L. Polygonaceae: *Polygonum* sp.

***Epiblema scudderiana* (Clemens)**
Fairfax (USNM).
15 April to 15 May.
Host Plants: Asteraceae (4).

***Epiblema strenuana* (Walker)**
[ragweed borer]
Arlington (USNM), Caroline (USNM), Fairfax (USNM), Goochland (EME), *Virginia Beach* (USNM).
15 April to 27 August.
Host Plants: Asteraceae (4) and Chenopodiaceae (1).

***Epiblema tripartitana* (Zeller)**
Fairfax (USNM).
20 May.
Host Plants: Probably Asteraceae.

***Epinotia heucherana* Heinrich**
Arlington (USNM).
8 June.
Host Plants: Saxifragaceae: *Heuchera americana* L.

***Epinotia lindana* (Fernald)**
Floyd (USNM), Grayson (USNM), Montgomery (USNM), Smyth (USNM).
27 September to 9 October.
Host Plants: Betulaceae (1) and Cornaceae (1), with most records from the latter family.

***Epinotia nanana* (Treitschke)**
[green spruce leafminer]
Fairfax (USNM).
19–23 April.
Host Plants: Pinaceae (1).

***Epinotia radicana* (Heinrich)**
Smyth (USNM).
2 September.
Host Plants: Cupressaceae (2) and Pinaceae (5).

***Epinotia septemberana* Kearfott**
Bath (USNM), Floyd (USNM).
20–27 September.
Host Plants: Ericaceae: *Rhododendron* sp. and *R. canadense* (L.) Torr. Pinaceae: *Picea mariana* (Mill.) Britton et al.

***Epinotia walkerana* (Kearfott)**
Arlington (EMDB), Fairfax (USNM).
27 May to 12 June.
Host Plants: Betulaceae: *Corylus* sp. and *C. americana* Marshall.

***Eucosma agricolana* (Walsingham)**
Fairfax (EMDB, USNM).
28 May to 2 July.
Host Plants: Asteraceae: *Artemisia* sp. and *A. vulgaris* L.

***Eucosma albiguttana* (Zeller)**
Hampton (USNM), *Virginia Beach* (USNM).
9 February (possibly reared) to 20 July.
Host Plants: Unknown.

***Eucosma cataclystiana* (Walker)**
Fairfax (EME, USNM).
30 May to 4 September.
Host Plants: Asteraceae: *Ambrosia* sp. and *Solidago* sp.

***Eucosma cocana* Kearfott**
[shortleaf pine cone borer]
Hanover (USNM), King and Queen (USNM, VT), Montgomery (VT), *Virginia Beach* (USNM, VT).
23 April to 11 May.
Host Plants: Pinaceae: *Pinus taeda* L.

***Eucosma derelicta* Heinrich**
Bath (USNM), Fairfax (USNM), Floyd (USNM), Giles (Milne & Milne, 1944), Northumberland (USNM).
21 July to 13 September (8 July; Milne & Milne, 1944).
Host Plants: Asteraceae: *Solidago* sp.

***Eucosma dorsisignatana* (Clemens)**
Bath (USNM), Dinwiddie (USNM), Fairfax (EMDB, USNM), Franklin (USNM), Halifax (USNM), Hanover (USNM), Russell (USNM).
17 August to 24 October
Host Plants: Asteraceae: *Solidago* sp., *S. canadensis* L., and *S. sempervirens* L.

***Eucosma fraudabilis* Heinrich**
Nottoway (USNM), Page (USNM).
6–15 July.
Host Plants: Unknown.

***Eucosma giganteana* (Riley)**
Franklin (USNM).
8 August.
Host Plants: Asteraceae: *Silphium perfoliatum* L.

***Eucosma gloriola* Heinrich**
[eastern pine shoot borer]
Fauquier (USNM), Hanover (USNM).
28 March to 24 April.
Host Plants: Pinaceae (3).

***Eucosma gomonana* Kearfott**
Arlington (USNM), Fairfax (USNM).
16 April to 4 May.
Host Plants: Unknown.

***Eucosma monitorana* Heinrich**
Fairfax (USNM).
28 May to 12 July.
Host Plants: Pinaceae: *Pinus* sp., *P. resinosa* Aiton, and *P. virginiana* Mill.

***Eucosma oraria* Wright**
Accomack (USNM), Northampton (USNM).
23 September to 6 October.
Host Plants: Unknown.

***Eucosma quinquemaculana* (Robinson)**
Virginia Beach (USNM).
8 September to 6 October.
Host Plants: Unknown.

***Eucosma robinsonana* (Grote)**
Isle of Wight (USNM), Nottoway (USNM), *Suffolk* (USNM).
8 June to 16 September.
Host Plants: Unknown.

***Eucosma similiana* (Clemens)**
Bath (USNM).
10 August.
Host Plants: Asteraceae: *Solidago* sp.

***Eucosma sombreana* Kearfott**
Montgomery (USNM).
31 August.
Host Plants: Asteraceae: *Helianthus* sp., *H. decapetalus* L., *H. giganteus* L., and *H. tuberosus* L.

***Eucosma tocullionana* Heinrich**
[white pine cone borer]
Albemarle (USNM), Fairfax (EMDB, USNM), Orange (USNM), Page (EMDB), Washington (USNM).
7 May to 20 July.

Host Plants: Pinaceae (4).

***Eucosma vagana* McDunnough**
Fairfax (USNM).
11 July.
Host Plants: Asteraceae: *Solidago* sp.

***Eucosma wandana* Kearfott**
Fairfax (USNM).
28 July.
Host Plants: Unknown; possibly Asteraceae.

***Eucosma* n. sp.**
Montgomery (USNM).
6 August.
Host Plants: Unknown.

***Gretchena amatana* Heinrich**
Bath (USNM), Fairfax (USNM), Floyd (USNM).
15 April to 27 May.
Host Plants: Possibly Juglandaceae.

***Gretchena bolliana* (Slingerland)**
[pecan bud moth]
Chesapeake (USNM), Loudoun (USNM), *Virginia Beach* (USNM).
21 May to 10 June (emergence dates, not field captures).
Host Plants: Juglandaceae: *Carya* sp., *C. aquatica* (F. Michx.) Nutt., *C. illinioensis* (Wagnerh.) K. Koch., *Juglans* sp., and *J. cinerea* L.

***Gretchena concitatricana* (Heinrich)**
Bath (USNM), Fairfax (USNM).
21 April to 3 June.
Host Plants: Juglandaceae: *Juglans nigra* L.

***Gretchena delicatana* Heinrich**
Fairfax (USNM).
16 June.
Host Plants: Unknown.

***Gretchena deludana* (Clemens)**
Bath (USNM), Chesterfield (USNM), Fairfax (USNM), Rockingham (USNM).
25 April to 25 May.
Host Plants: Unknown.

***Gretchena nymphana* Blanchard & Knudson**
Caroline (USNM), Fairfax (USNM).
14 April to 10 May.
Host Plants: Unknown.

***Gretchena watchungana* (Kearfott)**
Fairfax (USNM), Rockbridge (Wagner et al., 1995).
23–30 April.
Host Plants: Betulaceae: *Alnus* sp. Fagaceae: *Quercus* sp.

***Gypsonoma salicicolana* (Clemens)**
Fairfax (USNM).
17 July.
Host Plants: Salicaeae: *Salix* spp.

***Notocelia trimaculana* (Haworth)**
Dickenson (USNM), Fairfax (USNM), Montgomery (USNM), Patrick (EME), Rockingham (USNM).
30 April to 23 June.
Host Plants: Rosaceae: *Crataegus* sp., *Prunus spinosa* L., and *Pyrus communis* L.

***Pelochrista milleri* Wright**
Fairfax (USNM).
10 August.
Host Plants: Unknown.

***Pelochrista pallidipalpana* (Kearfott)**
Hampton (USNM), *Virginia Beach* (USNM).
19–20 July.
Host Plants: Unknown.

***Pelochrista womonana* (Kearfott)**
Arlington (USNM).
January (emergence dates, not field captures).
Host Plants: Asteraceae: *Cynara* sp., *Helianthus* sp., *H. annuus* L., and *H. divaricatus*.

***Pelochrista zomonana* (Kearfott)**
Fairfax (USNM).
12 June to 26 July.
Host Plants: Asteraceae: *Chrysanthemum* sp.

***Phaneta ambodaidaleia* Miller**
Fairfax (USNM).
20 March to 6 April.
Host Plants: Unknown.

***Phaneta autumnana* (McDunnough)**
Fairfax (USNM).
23 September to 1 October.
Host Plants: Unknown.

***Phaneta awemeana* (Kearfott)**
Smyth (USNM).
22 May.
Host Plants: Unknown.

***Phaneta ferruginana* (Fernald)**
Fairfax (USNM).
1–2 May.
Host Plants: Unknown.

***Phaneta formosana* (Clemens)**
"Virginia" (USNM).
1 June.
Host Plants: Asteraceae: *Solidago* sp.

***Phaneta kiscana* (Kearfott)**
Fairfax (USNM).
28 May.
Host Plants: Unknown.

***Phaneta ochrocephala* (Walsingham)**
Fairfax (USNM).
27 August to 4 September.
Host Plants: Asteraceae: *Xanthium* sp. and *X. strumarium* L.

***Phaneta ochroterminana* (Kearfott)**
Fairfax (USNM).
4–17 September.
Host Plants: Asteraceae: *Aster* sp. and *Solidago* sp.

***Phaneta parmatana* (Clemens)**
Fairfax (USNM).
15 May to 24 September.
Host Plants: Asteraceae: *Aster* sp. and *Symphyotrichum ciliolatum* (Lindl.) A. Love & D. Love.

***Phaneta radiatana* (Walsingham)**
Arlington (USNM).
4 June.
Host Plants: Asteraceae: *Solidago* sp.

***Phaneta raracana* (Kearfott)**
Fairfax (USNM).
10 August to 11 September.
Host Plants: Asteraceae: *Solidago* sp.

***Phaneta striatana* (Clemens)**
"Virginia" (USNM).
No capture data.
Host Plants: Unknown.

***Phaneta tomonana* (Kearfott)**
Fairfax (USNM).
4 September.
Host Plants: Asteraceae: *Aster* sp.

***Phaneta umbrastriana* (Kearfott)**
Fairfax (USNM), Floyd (USNM).
8–31 May.
Host Plants: Asteraceae: *Solidago* sp.

***Phaneta verna* Miller**
Fairfax (USNM).
18–27 April.
Host Plants: Unknown.

***Proteoteras aesculana* Riley**
[maple twigborer]
Fairfax (USNM), *Virginia Beach* (USNM).
6 April to 9 November.
Host Plants: Aceraceae: *Acer* sp. and *A. negundo* L. Sapindaceae: *Aesculus* sp. and *A. hippocastanum* L.

***Proteoteras crescentana* Kearfott**
Fairfax (USNM).
20 June to 12 July.
Host Plants: Aceraceae: *Acer negundo* L.

***Proteoteras moffatiana* Fernald**
Madison (SNPC), Montgomery (USNM), Smyth (USNM).
12 July to 31 August.
Host Plants: Aceraceae: *Acer rubrum* L. and *A. saccharinum* L. Caprifoliaceae: *Sambucus* sp. Rosaceae: *Rosa* sp.

***Proteoteras willingana* (Kearfott)**
[boxelder twig borer]
Fairfax (USNM).
20 June.
Host Plants: Aceraceae: *Acer* sp. and *A. negundo* L.

***Pseudexentera costomaculana* (Clemens)**
Henry (USNM), Rockingham (USNM), Smyth (USNM).
3 May to 17 July (mostly May).
Host Plants: Hamamelidaceae: *Hamamelis* sp.

***Pseudexentera cressoniana* (Clemens)**
Caroline (USNM), Fairfax (EME, USNM), Prince William (USNM).
31 March to 19 April.
Host Plants: Juglandaceae: *Carya* sp.

***Pseudexentera faracana* (Kearfott)**
Fairfax (EMDB, USNM).
10 February to 9 April.
Host Plants: Fagaceae: *Castanea* sp.

***Pseudexentera haracana* (Kearfott)**
Rockbridge (Wagner et al., 1995).
Larval collections.

Host Plants: Fagaceae: *Quercus* sp. and *Castanea* sp.

***Pseudexentera hodsoni* Miller**
Rockbridge (Wagner et al., 1995).
Larval collections.
Host Plants: Fagaceae: *Quercus* sp.

***Pseudexentera mali* Freeman**
[pale apple leafroller]
Fairfax (USNM).
6–19 April.
Host Plants: Rosaceae: *Crataegus* sp., *Malus coronaria* (L.) Mill., *M. coronaria* (L.) Mill., *Pyrus* sp., and *P. communis* L.

***Pseudexentera spoliana* (Clemens)**
Fairfax (EMDB, USNM), Rockbridge (Wagner et al., 1995).
19–25 April.
Host Plants: Aceraceae: *Acer* sp. Fagaceae: *Castanea* sp. and *Quercus* sp.

***Pseudexentera vaccinii* Miller**
Rockbridge (Wagner et al., 1995).
Larval collections.
Host Plants: Ericaceae: *Vaccinium* sp.

***Pseudexentera virginiana* (Clemens)**
Fairfax (USNM).
2 April.
Host Plants: Unknown.

***Pseudexentera* n. sp.**
Rockbridge (Wagner et al., 1995).
Larval collections.
Host Plants: Fagaceae: *Quercus* sp.

***Retinia comstockiana* Fernald**
[pitch twig moth]
Arlington (USNM), Caroline (USNM), Fairfax (USNM).
1–18 June.
Host Plants: Pinaceae: *Pinus banksiana* Lamb., *P. resinosa* Aiton, *P. rigida* Mill., *P. sylvestris* L., and *P. taeda* L.

***Retinia gemistrigulana* (Kearfott)**
Caroline (USNM), Chesterfield (USNM), Fairfax (USNM), King and Queen (USNM), Pulaski (USNM), *Virginia Beach* (USNM).
11 May to 7 June.
Host Plants: Presumably Pinaceae or Cupressaceae.

***Retinia virginiana* (Busck)**
Botetourt (USNM), Craig (USNM), Fairfax (USNM), Floyd (USNM), Hanover (USNM), Isle of Wight (USNM), James City (USNM), Montgomery (USNM).
20 April to 17 May.
Host Plants: Pinaceae: *Pinus virginiana* Mill.

***Rhopobota dietziana* (Kearfott)**
Caroline (USNM), Fairfax (USNM).
2 April to 25 July.
Host Plants: Aquifoliaceae: *Ilex* sp. and *I. verticillata* (L.) A. Gray.

***Rhopobota finitimana* (Heinrich)**
Caroline (USNM), Fairfax (USNM), *Suffolk* (USNM).
4 April to 20 July.
Host Plants: Aquifoliaceae: *Ilex* sp., *I. mucronatus* (L.) M. Powell et al., and *I. verticillata* (L.) A. Gray. Salicaceae: *Populus balsamifera* L.

***Rhyacionia busckana* Heinrich**
Arlington (USNM).
21 March to 30 May.
Host Plants: Pinaceae: *Pinus banksiana* Lamb., *P. ponderosa* C. Lawson, *P. resinosa* Aiton, and *P. sylvestris* L.

***Rhyacionia frustrana* (Scudder)**
[Nantucket pine tip moth]
Arlington (USNM), *Chesapeake* (USNM), Fairfax (EMDB, USNM), Hanover (VT), Henrico (USNM), King William (USNM, VT), Mathews (USNM), Northumberland (USNM), Southampton (VT), *Virginia Beach* (USNM).
6 January to 31 December (field captures mostly May to July; laboratory emergences in other months).
Host Plants: Pinaceae: *Pinus* spp.

***Rhyacionia rigidana* (Fernald)**
[pitch pine tip moth]
Augusta (USNM), Fairfax (EMDB, USNM), Hanover (USNM), King and Queen (USNM, VT).
28 February to 14 July.
Host Plants: Pinaceae: *Pinus* spp.

***Sonia canadana* McDunnough**
Fairfax (USNM), Smyth (USNM).
20 June to 26 July.
Host Plants: Aceraceae: *Acer* sp. Asteraceae: *Aster* sp., *Solidago* sp., and *Symphyotrichum novae-angeliae* (L.) G. L. Nesom.

***Sonia constrictana* (Zeller)**
Fairfax (USNM), *Virginia Beach* (USNM).
23 June to 25 July.
Host Plants: Unknown.

***Sonia paraplesiana* Blanchard**
Suffolk (USNM).
31 August.
Host Plants: Unknown.

***Spilonota ocellana* [Denis and Schiffermüller]**
[eyespotted bud moth]
Fairfax (USNM).
19 April to 21 May.
Host Plants: Anacardiaceae (1), Betulaceae (3), Elaeagnaceae (1), Ericaceae (1), Euphorbiaceae (1), Fagaceae (1), Juglandaceae (1), Myricaceae (1), Pinaceae (1), Polygonaceae (1), Rosaceae (9), and Salicaceae (1).

***Strepsicrates smithiana* (Walsingham)**
Chesapeake (USNM), *Hampton* (USNM), Isle of Wight (USNM), *Virginia Beach* (USNM).
24 March to 10 August.
Host Plants: Myricaceae (2) and Myrtaceae (2).

***Zeiraphera claypoleana* (Riley)**
Fairfax (USNM).
27 May.
Host Plants: Sapindaceae: *Aesculus glabra* Willd.

***Zeiraphera improbana* (Walker)**
Fairfax (USNM).
7 July.
Host plants: Juglandaceae (1), Pinaceae (3), and Salicaceae (1).

OLETHREUTINAE: GRAPHOLITINI

***Corticivora clarki* Clarke**
Fairfax (EME, USNM).
27–28 June.
Host plants: Unknown.

***Cydia caryana* (Fitch)**
[hickory shuckworm]
Arlington (USNM), Fairfax (USNM), *Virginia Beach* (USNM).
10 June to 27 July.
Host Plants: Juglandaceae: *Carya* sp., *C. illinoiensis* (Wagenh.) K. Koch, *C. ovata* (Mill.) K. Koch, and *Juglans nigra* L.

***Cydia grandicula* (Heinrich)**
Giles (USNM).
14–21 June.
Host Plants: Unknown.

***Cydia latiferreana* (Walsingham)**
[filbertworm]
Bath (USNM), Bedford (USNM), Caroline (USNM), Chesterfield (USNM), Fairfax (EME, USNM), Fauquier (USNM), Floyd (USNM), Franklin (USNM), Giles (Milne & Milne, 1944), Hanover (USNM), Isle of Wight (USNM), Montgomery (USNM), Northumberland (USNM), Page (EME), Patrick (USNM), Russell (USNM), Surry (USNM), *Virginia Beach* (USNM).
11 May to 11 October.
Host Plants: Betulaceae (1), Fagaceae (3), Juglandaceae (1), Proteaceae (1), Punicaceae (1), and Rosaceae (1).

***Cydia pomonella* (L.)**
[codling moth]
Accomack (USNM), Albemarle (VT), Fairfax (EME, USNM), Isle of Wight (VT), Tazewell (Stein, 1993).
18 April to 12 November.
Host plants: Fagaceae (1), Juglandaceae (1), Moraceae (1), Proteaceae (1), Rosaceae (5), and Rutaceae (1).

***Cydia toreuta* (Grote)**
[eastern pine seedworm]
Accomack (USNM), Fairfax (EME, USNM), Rockbridge (USNM), Southampton (USNM), *Suffolk* (USNM), *Virginia Beach* (USNM).
15 May to 2 July.
Host Plants: Pinaceae: *Pinus banksiana* Lam., *P. resinosa* Aiton, and *P. virginiana* Mill.

***Cydia* n. sp. 1**
Fairfax (USNM).
16 April.
Host Plants: Unknown.

***Cydia* n. sp. 2**
Fairfax (USNM).
2 May.
Host Plants: Unknown.

***Dichrorampha incanana* (Clemens)**
Fairfax (USNM).
6 June.
Host Plants: Unknown.

***Dichrorampha leopardana* (Busck)**
Fairfax (USNM).

1 August (emergence date of reared specimens).
Host Plants: Asteraceae: *Verbesina* sp. and *Ageratina* sp.

***Dichrorampha simulana* (Clemens)**
Fairfax (EMDB), Montgomery (USNM).
30 May to 30 June.
Host Plants: Possibly Asteraceae.

***Ecdytolopha insiticiana* Zeller**
[locust twig borer]
Accomack (USNM), Alleghany (USNM), Arlington (USNM), Bath (Skinner, 1921; USNM), Botetourt (USNM), Caroline (USNM), Charles City (USNM), Dickenson (USNM), Fairfax (EMDB, USNM), Floyd (USNM), Giles (Milne & Milne, 1944), Hanover (USNM), King William (VT), Montgomery (EMDB, USNM), Prince William (USNM), Richmond (USNM), Roanoke (VT), Wise (USNM).
21 April to 23 August.
Host Plants: Fabaceae: *Robinia* sp., *R. pseudoacacia* L., and *Wisteria* sp.

***Ecdytolopha mana* (Kearfott)**
Fairfax (USNM).
15 May.
Host Plants: Ulmaceae: *Celtis* sp.

***Grapholita eclipsana* (Zeller)**
Fairfax (EMDB, USNM), Giles (USNM).
18 April to 12 May, with a single record from 14 August.
Host Plants: Fabaceae: *Amorpha canescens* Pursh.

***Grapholita interstinctana* (Clemens)**
[clover head caterpillar]
Bath (Skinner, 1921), Fairfax (USNM), Montgomery (VT).
14 April to 10 May.
Host Plants: Fabaceae: *Trifolium* sp. and *Trifolium incarnatum* L.

***Grapholita molesta* (Busck)**
[oriental fruit moth]
Arlington (USNM), Charlotte (USNM), Fairfax (USNM).
21 May to 16 September.
Host Plants: Ebenaceae (1), Myrtaceae (2), Rosaceae (10), and Sapindaceae (1).

***Grapholita packardi* (Zeller)**
[cherry fruitworm]
Arlington (USNM), Fairfax (EME, USNM), *Virginia Beach* (USNM).
19 April to 3 September.
Host Plants: Rosaceae (6) and Ericaceae (1).

***Grapholita prunivora* (Walsh)**
[lesser appleworm]
Arlington (USNM), Fairfax (USNM).
12 May to 3 September.
Host Plants: Rosaceae (6); occasionally in galls of aphids or fungus.

***Gymnandrosoma punctidiscanum* Dyar**
Bath (USNM), Caroline (USNM), Fairfax (EMDB, USNM), Floyd (USNM), Giles (USNM), Hanover (USNM), Isle of Wight (USNM), Lancaster (USNM), *Virginia Beach* (USNM).
12 May to 1 September.
Host Plants: Fabaceae: *Robinia* sp.

***Larisa subsolana* Miller**
Fairfax (USNM), *Suffolk* (USNM), *Virginia Beach* (USNM).
29 April to 23 July.
Host Plants: Aquifoliaceae: *Ilex mucronatus* (L.) M. Powell et al. Juglandaceae: *Carya* sp. and *C. illinoiensis* (Wagenh.) K. Koch.

***Pammene perstructana* (Walker)**
Washington (USNM).
7 May.
Host Plants: Unknown.

***Pseudogalleria inimicella* (Zeller)**
Giles (Milne & Milne, 1944), *Virginia Beach* (USNM).
22 May (8 July; Milne & Milne, 1944).
Host Plants: Smilacaceae: *Smilax* sp. and *S. herbacea* L.

***Satronia tantilla* Heinrich**
Fairfax (EME, USNM).
21 April to 26 June.
Host Plants: Unknown.

***Sereda tautana* (Clemens)**
Fairfax (USNM), Rockbridge (Wagner et al., 1995).
10–20 April.
Host Plants: Fagaceae: *Quercus* spp.

***Talponia plummeriana* (Busck)**
Fairfax (USNM).
18 April to 23 May.
Host Plants: Annonaceae: *Asimina triloba* (L.).

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Choristoneura rosaceana (Harris), the obliquebanded leafroller.

Appendix 1. Number of records per month for each species; numbers in italics refer to laboratory emergences; + = species with capture dates unknown; * = species known from larval collections only.

Tribe/species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
TORTRICINI												
Acleris cervinana	1		1	2						5	2	
Acleris chalybeana				6			*1*			1		
Acleris curvalana					6	14	1					
Acleris ferrugana		1			1		*1*			*1*		
Acleris flavivittana		1	7	5					1		1	2
Acleris forbesana			1									1
Acleris hastiana		2		1								
Acleris hudsoniana						1						
Acleris kearfottana		3									1	1
Acleris logiana placidana				2			1			1		
Acleris maccana				2						1		
Acleris macdunnoughi									2			
Acleris maculidorsana		1	1			*2*	1					
Acleris minuta					6							
Acleris negundana		1	1		9	3	3					1
Acleris nigrolinea								2				
Acleris robinsonana		2					1					
Acleris schalleriana virburnana		5	1		1	15	7	7		1	1	2
Acleris semiannula		1										
Acleris semipurpurana					53	51	4					
Acleris simpliciana					2							
*Acleris subnivana**												
Acleris variana									1			
Acleris n. sp. 1							1					
Acleris n. sp. 2										1		
CNEPHASIINI												
Decodes basiplaganus									5			
ARCHIPINI												
Adoxophyes furcatana					1	1		1				
Archips argyrospila						2	6					
Archips cerasivorana							2					
Archips fervidana						6, *9*	8, *13*	2				
Archips grisea					2	5	1					
Archips magnoliana							1					
Archips nigriplagana						1						
Archips purpurana						2	4					
Archips rileyana							*11*					
Archips semiferana						1	3					
Argyrotaenia alisellana					60	27	1					
Argyrotaenia floridana						6	3		2			
Argyrotaenia juglandana						4			1			
Argyrotaenia mariana				5	18	1	1					
Argyrotaenia occultana				1								
Argyrotaenia pinatubaba				2	1	2	4					
Argyrotaenia quercifoliana					20	47	5	2	1			
Argyrotaenia tabulana					6							
Argyrotaenia velutinana	*1*		11	32, *1*	11	30, *1*	29, *1*	14, *4*	14			
Choristoneura fractivittana					25	2						
Choristoneura fumiferana						14	1					
Choristoneura obsoletana					1, *4*	1	1	16, *2*	16			

Tribe/species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ARCHIPINI (continued)												
Choristoneura parallela					10	12	9	5	4			
Choristoneura pinus						6	2	1				
Choristoneura rosaceana					70	64, *1*	56	44, *1*	34	2		
Clepsis clemensiana							1	1				
Clepsis melaleucana					37	15	1					
Clepsis peritana				10	37	62	37	56	52	9		
Clepsis persicana						10						
Clepsis virescana					4	6	11	10	14			
Cudonigera houstonana							1					
Lozotaenia exomilana							1					
Pandemis lamprosana					6	5	1	1	1			
Pandemis limitata					11	16	2	9, *2*	30			
Syndemis afflictana				16	6							
Xenotemna pallorana					8	8		2				
SPARGANOTHINI												
Amorbia humerosana			1	7	52	47	1					
Coelostathma discopunctana					12	12	2	10	2			
Coelostathma n. sp.					1							
Niasoma metallicana								1				
Platynota exasperatana					1	2		3	1			
Platynota flavedana					11	9	15	5	9, *1*			
Platynota idaeusalis					13	14	18	15	6			
Platynota rostrana						6		2	1			
Platynota stultana				*3*					*3*	*6*	*5*	
Sparganothis (*Cenopis*) *albicaudana**												
Sparganothis (*Cenopis*) *cana*						1						
Sparganothis (*Cenopis*) *diluticostana*						6	1					
Sparganothis (*Cenopis*) *directana*						1	4	1				
Sparganothis (*Cenopis*) *lamberti*						1		1				
Sparganothis (*Cenopis*) *pettitana*					1	2						
Sparganothis (*Cenopis*) *reticulatana*					2	1	9	12	3			
Sparganothis (*Cenopis*) *saracana*							1					
Sparganothis (*Cenopis*) n. sp.							1					
Sparganothis (*S.*) *bistriata*							7		1			
Sparganothis (*S.*) *distincta*						5, *3*		10, *1*				
Sparganothis (*S.*) *sulfureana*					1	11	11	11, *1*	21, *3*	10		
Sparganothis (*S.*) *tristriata*								2				
Sparganothis (*S.*) *unifasciana*						4	1					
Sparganothis (*S.*) *violaceana*						2						
Sparganothis (*S.*) *xanthoides*						2	4	3				
Sparganothoides lentiginosana						10	1	8	25	1		
EULIINI												
Anopina ednana							8	5				
Eulia ministrana						11						
COCHYLINI												
Aethes angustana					1, *1*				24	1		
Aethes argentilimitana					3		2		1			
Aethes atomosana									1			
Aethes floccosana						3						
Aethes interruptofasciata					1							
Aethes promptana									2			
Aethes sexdentata						1						

Tribe/species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
COCHYLINI (continued)												
Aethes n. sp. 1						1		3				
Aethes n. sp. 2					2	1	4	1				
Carolella bimaculana									1			
Carolella sartana						1	2	1				
"*Cochylis*" *aurorana*									2			
"*Cochylis*" *hoffmanana*				2	3		1	1				
"*Cochylis*" *oenotherana*									1			
"*Cochylis*" *temerana*				4								
Henricus contrastana						4						
Phalonidia lepidana					2							
Phtheochroa riscana						1		4				
Phtheochroa terminana						2		10	8			
Platphalonidia nr. *felix*							1	2				
Rudenia leguminana					1			1				
Thyraylia n. sp. +												
BACTRINI												
Bactra furfurana						6	9	4				
Bactra maiorina						2	*3*					
Bactra verutana						2	2	3	4	1	2	
Endothenia hebesana	*5*			2	9	31	35	10, *3*	3			
Endothenia montanana						1						
Endothenia nubilana								1	1			
Hulda impudens					1	10	12	5	3			
OLETHREUTINI												
Celypha cespitana					6	8	16	6	19			
Episimus argutanus					4, *2*	8, *3*	11	8	1			
Episimus tyrius					6	3	4					
Eumarozia malachitana						2	3	10	8, *2*	3		
Hedya chionosema				1	1		*1*					
Hedya cyanana					1, *1*		*1*	*1*				
Hedya ochroleucana						1						
Metendothenia separatana								1				
Olethreutes appendiceum					4	5	1					
Olethreutes astrologana					8	6						
*Olethreutes atrodentata**												
Olethreutes auricapitana						1						
Olethreutes bipartitana					1	1		1				
Olethreutes brunneopurpurata							1	*2*				
Olethreutes concinnana						3	3					
Olethreutes coruscana					12	6						
Olethreutes corylana					1							
Olethreutes fasciatana					15	71	11					
Olethreutes ferriferana					2	1, *3*						
Olethreutes ferrolineana					1	1						
Olethreutes footiana						*1*						
Olethreutes glaciana						1						
Olethreutes griseoablana						8			1			
Olethreutes hamameliana					1	3						
Olethreutes inornatana					*1*		3	1				
*Olethreutes lacunana**												
Olethreutes merrickanum							1					
Olethreutes monetiferana					1							
Olethreutes nitidana							1					

Tribe/species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
OLETHREUTINI (continued)												
Olethreutes olivaceana					3				1			
Olethreutes osmundana							1					
Olethreutes permundana						4	4	3				
Olethreutes troglodana						1						
Orthotaenia undulana						13						
Paralobesia liriodendrana					3	1, *9*		3				
Paralobesia piceana									1			
Paralobesia rhoifructana					*8*		1	1				
Paralobesia spiraeifoliana				1	1							
Paralobesia viteana					1	1	*1*	*1*				
Paralobesia yaracana						1	1					
Phaecasiophora confixana					2	10	3	5				
Phaecasiophora niveiguttana					1	26	3	5				
Pristerognatha agilana					3							
Zomaria interruptolineana				3	2		1	1	1			
ENARMONIINI												
Ancylis burgessiana					1	*1*						
Ancylis carbonana						2						
Ancylis comptana				5			2	1				
Ancylis discigerana					2	1						
Ancylis divisana					3	3	4, *2*	*6*	1			
Ancylis fuscociliana						1						
Ancylis geminana					1							
Ancylis goodelliana						1						
Ancylis laciniana					22	5						
Ancylis metamelana					1	1	2		1			
Ancylis muricana					1		1					
Ancylis nubeculana					2							
Ancylis platanana				1	7				1			
Ancylis semiovana						1						
Ancylis subaequana						5						
EUCOSMINI												
Catastega aceriella						2	1					
Catastega timidella						1						
Chimoptesis gerulae		1										
*Chimoptesis pennsylvaniana**												
Epiblema boxcana					3							
Epiblema brightonana						1	1	1				
Epiblema carolinana								2				
Epiblema desertana				1	2	1						
Epiblema infelix						2						
Epiblema numerosana							2					
Epiblema obfuscana						1						
Epiblema otiosana					1	3	2	4				
Epiblema scudderiana				2	1							
Epiblema strenuana				3	17	13	1	4, *1*				
Epiblema tripartitana					1							
Epinotia heucherana						1						
Epinotia lindana									1	3		
Epinotia nanana				3								
Epinotia radicana									7			
Epinotia septemberana									2			
Epinotia walkerana					1	1						

Tribe/species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
EUCOSMINI (continued)												
Eucosma agricolana					1	5	1					
Eucosma albiguttana		1					7					
Eucosma cataclystiana					1	5	7	7	1			
Eucosma cocana				2	7							
Eucosma derelicta								8	2			
Eucosma dorsisignatana								1	19	16		
Eucosma fraudabilis							2					
Eucosma giganteana								1				
Eucosma gloriola			1	1								
Eucosma gomonana				1	2							
Eucosma monitorana					1	1	1					
Eucosma oraria									1	4		
Eucosma quinquemaculana									4	1		
Eucosma robinsonana						2			2			
Eucosma similiana								1				
Eucosma sombreana								1				
Eucosma tocullionana					3		5, *3*					
Eucosma vagana							1					
Eucosma wandana							1					
Eucosma n. sp.								2				
Gretchena amatana				2	4							
Gretchena bolliana					*1*	*2*	*1*				*2*	
Gretchena concitatricana				1	2	1						
Gretchena delicatana						1						
Gretchena deludana				6	12							
Gretchena nymphana				2	1							
Gretchena watchungana				3								
Gypsonoma salicicolana							1					
Notocelia trimaculana				1	10	8						
Pelochrista milleri								1				
Pelochrista pallidipalpana							5					
Pelochrista womonana	*2*											
Pelochrista zomonana						2	1					
Phaneta ambodaidaleia			1	1								
Phaneta autumnana									3	2		
Phaneta awemeana					3							
Phaneta ferruginana					2							
Phaneta formosana						2						
Phaneta kiscana					3							
Phaneta ochrocephala								2	3			
Phaneta ochroterminana									2			
Phaneta parmatana					1	1		5	18			
Phaneta radiatana						1						
Phaneta raracana								3	9			
Phaneta striatana +												
Phaneta tomonana									1			
Phaneta umbrastriana					4							
Phaneta verna				5								
Proteoteras aesculana				1		2	8	2			1	
Proteoteras crescentana						1	1					
Proteoteras moffatiana							2	2				
Proteoteras willingana						1						

Tribe/species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
EUCOSMINI (continued)												
Pseudexentera costomaculana					4		1					
Pseudexentera cressoniana			1	3								
Pseudexentera faracana		2		4								
*Pseudexentera haracana**												
*Pseudexentera hodsoni**												
Pseudexentera mali				4								
Pseudexentera spoliana				3	*6*							
*Pseudexentera vaccinii**												
Pseudexentera virginiana				1								
Pseudexentera n. sp.*												
Retinia comstockiana						1, *2*						
Retinia gemistrigulana					7	14						
Retinia virginiana				2, *4*	4, *1*							
Rhopobota dietziana				2	1		2					
Rhopobota finitimana				2, *5*			2					
Rhyacionia busckana			8		3							
Rhyacionia frustrana	*3*	*10*	*23*	3, *47*	13	46, *1*	36	2			*5*	*7*
Rhyacionia rigidana		1	1	*12*		3	4					
Sonia canadana						2	2					
Sonia constrictana						1	2					
Sonia paraplesiana								1				
Spilonota ocellana				1	3							
Strepsicrates smithiana			1			1, *8*	15, *1*	4				
Zeiraphera claypoleana					1							
Zeiraphera improbana							1					
GRAPHOLITINI												
Corticivora clarki						2						
Cydia caryana				*1*	*3*	3	1, *1*	*1*				
Cydia grandicula						1						
Cydia latiferreana					3		11, *7*	36	33	1		
Cydia pomonella	*2*			5	10	9	16	5		1	1	
Cydia toreuta				*4*	6	9	5	*1*				
Cydia n. sp. 1				1								
Cydia n. sp. 2					1							
Dichrorampha incanana						1						
Dichrorampha leopardana								*2*				
Dichrorampha simulana					1	4						
Ecdytolopha insiticiana	*1*			7	32, *1*	22, *11*	16, *27*	8, *13*				
Ecdytolopha mana					1							
Grapholita eclipsana				6	2			1				
Grapholita interstinctana				2	1							
Grapholita molesta				*1*	1, *25*	*1*	1, *7*	1, *12*	2	*1*		
Grapholita packardi				1	1	4, *1*	1		2, *4*			
Grapholita prunivora	*1*				1				1			
Gymnandrosoma punctidiscanum					5	9	6	11	1			
Larisa subsolana				1		17	4					
Pammene perstructana					1							
Pseudogalleria inimicella					1							
Satronia tantilla				1		1						
Sereda tautana				3								
Talponia plummeriana				1	9							

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Decline of the Freshwater Mussel Fauna of the North Fork and South Fork Shenandoah Rivers, Virginia

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ABSTRACT

The North and South forks of the Shenandoah River in Virginia flow through predominantly agricultural areas and have been subjected to degradation by point and non-point source pollution (including mercury contamination from factory spills and potential arsenic contamination from pesticide use), sedimentation, alteration of hydrology by impoundments, and other alterations to their flows. The historical mussel fauna of both drainages has not been well documented. A review of published literature, museum collection data, and unpublished reports and field survey data reveals that seven species (*Alasmidonta undulata*, *Alasmidonta varicosa*, *Elliptio complanata*, *Elliptio fisheriana*, *Lampsilis ovata*, *Lasmigona subviridis*, and *Strophitus undulatus*) have been found in the North Fork Shenandoah River (NFSR) watershed. Six of these species (all except *E. fisheriana*) are also known from the South Fork Shenandoah River (SFSR) drainage, as is possibly *Lampsilis cariosa*. *Pyganodon cataracta*, a primarily lentic species, has been recorded once from each drainage, but it is not a member of the free-flowing riverine fauna.

Surveys conducted in the NFSR and SFSR in the 1990s and early 2000s suggested significant declines in mussel populations. During 2008-2009, 87 surveys were conducted at 84 unique sites in these drainages in an effort to assess the current status of the entire freshwater mussel community. Only one species (*E. complanata*) was observed alive in the NFSR drainage and the mainstem SFSR, whereas live individuals of three species (*A. undulata*, *E. complanata*, and *S. undulatus*) were found in headwater tributaries of the SFSR. Shell material was found for all lotic species previously recorded from these drainages with the exception of *L. subviridis*. The results of the 2008-2009 surveys suggest that there has been a near total loss of the mussel fauna of the Shenandoah River drainage in Virginia during the past century.

Key words: *Alasmidonta*, *Elliptio*, freshwater mussel, *Lampsilis*, *Lasmigona*, Shenandoah River, *Strophitus*, Unionidae, Virginia.

INTRODUCTION

Freshwater mussels (Order Unionoida) are of high conservation concern (Williams et al., 1993; Strayer et al., 2004). Approximately 40% (115 of 288) of the United States species are listed as critically imperiled or imperiled by NatureServe (Master et al., 2000). Thirty-seven species (about 12%) are presumed to be extinct or possibly extinct (Master et al., 2000). Twenty percent of the U.S. mussel fauna receives some federal protection under the Endangered Species Act (Master et al., 2000). Almost one quarter of Virginia's freshwater mussel species (20 of 81) are federally listed (Roble, 2010). The demise of many mussel species has been linked to the degradation of water quality and loss of aquatic habitats due to sedimentation or channel alteration (Helfrich & Neves, 2003; Strayer et al., 2004).

In 2006, the Shenandoah River was ranked as the fifth most "endangered" river in the United States by the conservation group American Rivers (2006). High population growth, suburban development, and recent evidence of fish kills within the drainage contributed to this ranking. With regard to the freshwater mussel fauna, historical chemical (i.e., mercury) pollution essentially extirpated mussel populations of the South Fork Shenandoah River (SFSR; Carter, 1977), but the North Fork Shenandoah River (NFSR) was thought to

be unaffected. Mercury, in the form of methyl mercury, has been shown to bioaccumulate in freshwater mussel tissue and may cause both hormonal changes and potential shifts in energy allocation in affected individuals (Kernaghan et al., 2011). The impacts of mercury on freshwater fish are also well documented, and include reduced reproductive success, behavioral changes that may increase mortality, and direct mortality (Schweiger et al., 2006). Since fish are hosts for mussel glochidia, it is plausible that mercury pollution may indirectly impact mussel reproduction; however, further studies are needed to examine this.

Additionally, there was heavy use of lead arsenate as a pesticide throughout the Shenandoah Valley from the late 1800s to the 1950s (VDCR-DSW, 2009). High levels of arsenic have been measured in fish tissue samples taken from the Shenandoah Valley. It is hypothesized that these high levels may be related to the pesticide, or to the use of arsenic as an additive to poultry feeds and subsequent excretion in poultry manure (VDCR-DSW, 2009). Arsenic can bioconcentrate in an organism, but it does not bioaccumulate up the food chain (Eisler, 1988). The impacts of arsenic on an organism are variable even between closely related species (Eisler, 1988). There is little published data concerning the effects of arsenic on freshwater mussel species, but marine mussels have been shown to bioconcentrate arsenic and exhibit slower growth rates (Eisler, 1988). It is unknown if the presence of arsenic in the Shenandoah River system impacted the mussel fauna either directly or indirectly.

Historically, the NFSR and SFSR drainages were sampled on several occasions (1912-1968) by a number of eminent malacologists, including Arnold E. Ortmann, Joseph P. E. Morrison, William J. Clench, and David H. Stansbery (see details below). More recently, surveys of selected sites in the NFSR by biologists from the Virginia Department of Conservation and Recreation – Division of Natural Heritage (DCR-DNH) during the early to mid-1990s suggested that mussel populations had seriously declined based on encounters with high numbers of fresh dead and relict shell material and few live individuals. In an effort to assess the current status of the entire freshwater mussel community of the NFSR and SFSR drainages, surveys were conducted during 2008-2009 by DCR-DNH. In particular, species of state concern were targeted, including the Brook Floater (*Alasmidonta varicosa*, state endangered), Green Floater (*Lasmigona subviridis*, state threatened), and Yellow Lampmussel (*Lampsilis cariosa*, state special concern [category subsequently abolished]).

STUDY AREAS

North Fork Shenandoah River

The NFSR mainstem flows through the Valley and Ridge physiographic province of Virginia for approximately 107 miles (172 km), draining an area of 1033 mi^2 (2675 km^2; Krstolic et al., 2006). The watershed is characterized by rolling hills and valleys and is bordered to the east by the Massanutten Mountains. The watershed drains all of Shenandoah County and portions of Frederick, Page, Rockingham, and Warren counties, Virginia and Hardy County, West Virginia (Fig. 1). The headwaters of the mainstem NFSR are in Hardy County, West Virginia and Rockingham County, Virginia. From the headwaters, the river flows east before turning northeast in Timberville, roughly paralleling Interstate 81 as far as Strasburg. At Strasburg, the NFSR turns east again, paralleling Interstate 66, until joining the SFSR in Front Royal to form the Shenandoah River.

The ridges of the physiographic region are formed by resistant materials such as quartzite and sandstone, while the valleys are comprised of more highly erodible limestone, shale, and dolomite (Krstolic et al., 2006). The upper (headwater) section of the NFSR cuts through primarily sandstone formations and forms wide meanders along the eastern edge of the valley. After the NFSR passes Edinburg, the meanders become very narrow (called the Seven Bends area), where it follows fracture zones in the Martinsburg shale (Hack & Young, 1959). In the middle and lower reaches, the NFSR has cut down to the bedrock, thus the channel is wide and shallow (Krstolic et al., 2006).

Alteration of the NFSR channel began in the early 1800s with wing dams and cut-throughs of bedrock ledges built to facilitate river navigation (Trout, 1997). Today, the NFSR is crossed by several low-water bridges. In addition, six dams, ranging in height from 5 to 16 ft (1.5-4.8 m), were built between 1900 and the 1920s, primarily for hydroelectric power and water supply sources for surrounding cities.

South Fork Shenandoah River

The SFSR mainstem flows through the Valley and Ridge physiographic province of Virginia for approximately 95 miles (153 km), draining an area of 1671 mi^2 (4328 km^2). Similar to the NFSR, rolling hills and valleys characterize the watershed, which is bordered to the east by the Blue Ridge Mountains. The northern portion of the drainage is bordered to the west

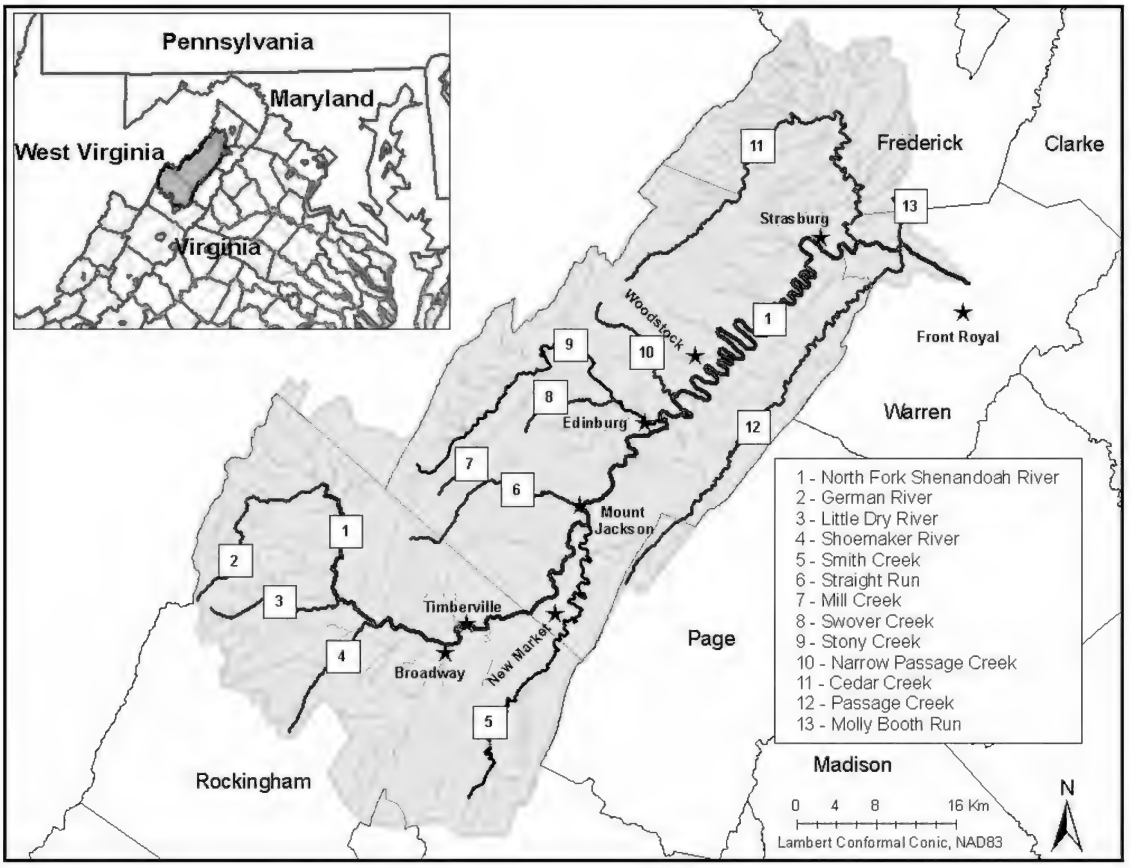

Fig. 1. Drainage area (gray shaded) of the North Fork Shenandoah River, Virginia.

by the Massanutten Mountains. The watershed drains portions of Augusta, Rockingham, Page, and Warren counties, Virginia (Fig. 2). The SFSR begins in Port Republic, Virginia at the confluence of the North and South rivers. It flows generally to the northeast, roughly parallel to U.S. Route 340. It meets the NFSR at Front Royal, Virginia to form the Shenandoah River.

The upper reaches of the SFSR and its main headwater tributaries (i.e., North, Middle, and South rivers) flow through the Massanutten Mountain syncline, which extends for about 30 miles (48 km) from the southwest end of the mountain to near the junction of U.S. Routes 340 and 11 (Frye, 1986). The core of the syncline here is the erodible Martinsburg shale. As the SFSR continues north, tight meanders are common where it follows the fracture zones of the Martinsburg shale (Hack, 1965). Similar to the NFSR, the middle and lower reaches of the SFSR have cut down to the bedrock, thus the channel is wide and shallow.

The SFSR from Port Republic to Front Royal was open to navigation in 1807 (Trout, 1997). This included construction of wing dams, cut-throughs of bedrock ledges, and mill-shoots (Trout, 1997). Today, there are four dams, constructed in the 1920s, primarily for hydroelectric power. They range from 15 to 28 feet (4.6-8.5 m) high. In addition, the SFSR is crossed by several low-water bridges.

HISTORICAL MUSSEL FAUNA OF THE SHENANDOAH RIVER DRAINAGE

The historical mussel fauna of the Shenandoah River drainage is not well documented, although Ortmann (1919) reported seven species and Johnson (1970) nine species from this drainage (Table 1). To supplement these reports, we searched eight online mollusk collection databases for specimen records from the Shenandoah River drainage. Collectively, the databases from the Academy of Natural Sciences of Philadelphia (ANSP, 22 records, 1916-1980, six others without dates) Carnegie Museum of Natural History (CMNH, 21 records, 1911-1937, two others without dates), Museum of Comparative Zoology, Harvard University (MCZ, 14 records, 1934-1968), National Museum of Natural History (NMNH, 14 records, 1934-

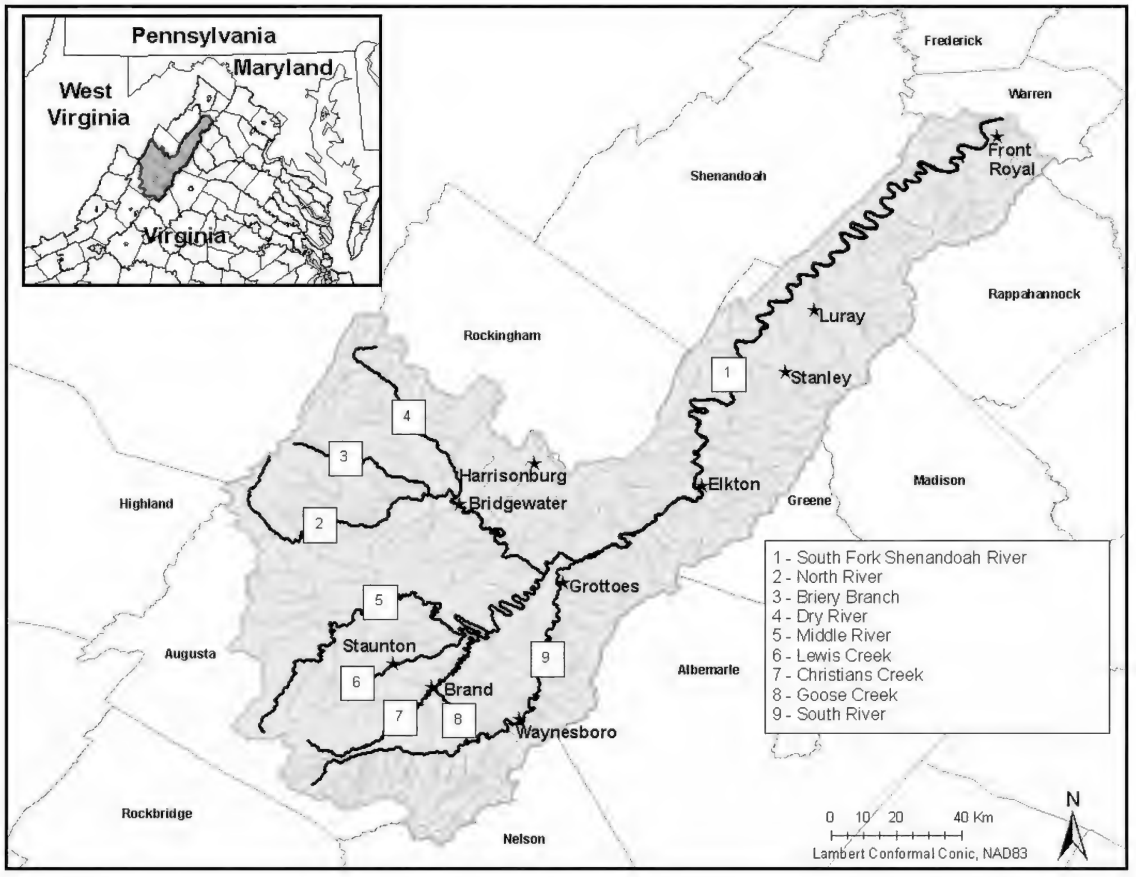

Fig. 2. Drainage area (gray shaded) of the South Fork Shenandoah River, Virginia.

1970, 10 others without dates), Museum of Biological Diversity, Ohio State University (OSUM, 11 records, 1968-1979), and the Museum of Zoology, University of Michigan (UMMZ, six records, 1928-1950, four others without dates), yielded records for nine mussel species (Table 1; no records were found in the online databases of the Illinois Natural History Survey or the Florida Museum of Natural History). Based on these sources (specimens not examined), seven species are recorded from the NFSR drainage, represented by 26 records spanning collection dates from 1912 to 1970 (plus eight collections without dates). These species are *Alasmidonta undulata* (Triangle Floater), *Alasmidonta varicosa*, *Elliptio complanata* (Eastern Elliptio), *Elliptio fisheriana* (Northern Lance), *Lampsilis ovata* (Pocketbook), *Lasmigona subviridis*, and *Strophitus undulatus* (Creeper). Available records for the Shenandoah River mainstem indicate a similar species composition. A search of museum and literature records revealed the historical presence of a similar mussel fauna in the SFSR drainage, including all of the NFSR species except *E. fisheriana* and the addition of *Lampsilis cariosa* (but see below).

Pyganodon cataracta (Eastern Floater) has been recorded from each drainage once. Ortmann collected this species (CMNH #61.5919) in 1912 along the South River at Waynesboro, noting (Ortmann, 1919: 157) that the specimens were "thin-shelled creek-form from a quiet pool." In 2005, two live individuals were found in Stony Creek above Lake Laura in the NFSR drainage (The Catena Group, 2006). This species thrives in nutrient-rich, often man-made impoundments and is not a member of the free-flowing riverine fauna.

In addition to the review of museum collection databases for historical records, we obtained field survey information from more recent literature, unpublished reports and field survey data, personal communications with malacologists, and recent collections (specimens examined) in the Virginia Museum of Natural History (Table 2). Fifteen total sources were found, collectively accounting for 84 surveys conducted between 1990 and 2007. The following is a brief summary of the known occurrences for each species in the NFSR and SFSR based on this historical information (Table 1) and known recent (herein defined as 1990-2007) surveys (Table 2).

Table 1. Historical (pre-1990) museum records of freshwater mussels from the Shenandoah River drainage. Records are taken from the following sources: Academy of Natural Sciences of Philadelphia (ANSP, Philadelphia, PA), Carnegie Museum of Natural History (CMNH, Pittsburgh, PA), Museum of Comparative Zoology (MCZ, Harvard University, Cambridge, MA), National Museum of Natural History (NMNH, Smithsonian Institution, Washington, DC), Ohio State University Museum of Biological Diversity (OSUM, Columbus, OH), University of Michigan Museum of Zoology (UMMZ, Ann Arbor, MI), Ortmann (1919), Johnson (1970), Clarke (1981), and the personal collection of A. Gerberich (via R. Neves, pers. comm.). 1 - same as CMNH record; 2 - cites Ortmann (1919); 3 - cites 'USNM' = NMNH; 4 - same as MCZ record. Locations or collection events that are known or likely to be equivalent are indicated with the same superscript letter.

River Location	*Alasmidonta undulata*	*Alasmidonta varicosa*	*Elliptio complanata*	*Elliptio fisheriana*	*Lampsilis cariosa*	*Lampsilis ovata*	*Lasmigona subviridis*	*Pyganodon cataracta*	*Strophitus undulatus*
North Fork Shenandoah River (NFSR) Drainage									
NFSR Broadway	CMNH Ortmann[1] Johnson[2] Clarke[2]		CMNH Ortmann[1] as *E. violaceus*						CMNH Ortmann[1]
NFSR Mt. Jackson			UMMZ						
NFSR E of Woodstock (possibly Burnshire Bridge, Rt. 758)		MCZ NMNH Johnson[4]	MCZ Johnson[4] Clarke[4]	MCZ as *E. productus* Johnson as *E. lanceolata*		MCZ as *L. ovata* *ventricosa*			MCZ as *S. rugosus* Johnson
NFSR Stonewall Mill (= Rt. 663)		NMNH							
NFSR 'on 5th bend of 7 bends' ca. 3 mi E Woodstock		OSUM	OSUM	OSUM as *E. producta*					OSUM
NFSR VA Rt. 55 bridge, ca. 2 mi SE Strasburg		MCZ [c] OSUM [c] Gerberich	NMNH MCZ [c] OSUM [c]	NMNH as *E. angustatus* MCZ [c] as *E. lanceolata* OSUM [c] as *E. producta*		NMNH as *L.* *ventricosa* MCZ [c] as *L. ovata* *ventricosa* OSUM [c] as *L. cardium*	NMNH MCZ [c] OSUM [c]		NMNH
NFSR Riverton			UMMZ as *E. dilatata*						
Passage Creek 2 mi SW Seven Fountains	NMNH		Johnson[3]						
South Fork Shenandoah River (SFSR) Drainage									
Christians Creek ca. 4 mi SE Staunton, at Brand	MCZ [d] OSUM [d]								MCZ [d] OSUM [d]
North River Weyers Cave			Johnson						
South River Waynesboro	CMNH Ortmann[1] Johnson[2]	CMNH Ortmann[1]	ANSP CMNH Ortmann[1] as *E. violaceus*					CMNH Ortmann[1] Johnson[2]	CMNH Ortmann[1] Johnson[2]
SFSR Elkton	CMNH Ortmann[1] Johnson[2] Clarke[2]	CMNH Ortmann[1]	CMNH Ortmann[1] as *E. violaceus*				CMNH Ortmann[1] Johnson[2]		CMNH Ortmann[1] Johnson[2]

Table 1 (continued).

River Location	*Alasmidonta undulata*	*Alasmidonta varicosa*	*Elliptio complanata*	*Elliptio fisheriana*	*Lampsilis cariosa*	*Lampsilis ovata*	*Lasmigona subviridis*	*Pyganodon cataracta*	*Strophitus undulatus*
South Fork Shenandoah River (SFSR) Drainage									
SFSR US Rt. 211 W of Luray							NMNH UMMZ		UMMZ
SFSR below Luray			ANSP			ANSP			ANSP
SFSR 2 mi W Compton		ANSP as *A. marginata*	ANSP			ANSP	ANSP		ANSP
SFSR Hazard Mill Rec. Area, 1.5 mi W Bentonville			ANSP			ANSP			
SFSR Rt. 613 near Bentonville [a]		ANSP as *A. marginata*	ANSP NMNH UMMZ			NMNH	ANSP		ANSP NMNH
SFSR ca. 8 mi SW Front Royal [a]			NMNH [e] UMMZ [e]		NMNH				NMNH
SFSR 2 mi NW Limeton		ANSP as *A. marginata*	ANSP			ANSP as *L. cardium*			
SFSR Front Royal			UMMZ						
SFSR Riverton		MCZ Johnson							
Shenandoah River (SR) Mainstem									
SR Front Royal							NMNH		
SR 7.0 mi SE Berryville (=US Rt. 17/50)				UMMZ as *E. shepardiana*		UMMZ			
SR ESE Berryville [b]						MCZ			
SR VA Rt. 7 [b]			UMMZ			NMNH as *L. ventricosa* UMMZ			
SR Ashby Gap to Snickers Gap (= US Rt. 17 to VA Rt. 7)	NMNH	NMNH				NMNH as *L. ventricosa*	NMNH		NMNH
SR Harpers Ferry, Jefferson Co., West Virginia	ANSP CMNH Ortmann[1] Johnson Clarke[2]	ANSP CMNH UMMZ Ortmann[1]	CMNH UMMZ	ANSP as *E. fisherianus* & *E. lanceolatus* CMNH as *E. producta* Ortmann as *E. cupreus*	CMNH	CMNH & UMMZ as *L. cardium* Johnson	CMNH Ortmann[1] Johnson		ANSP
SR Jefferson Co., West Virginia				ANSP, MCZ, & UMMZ as *E.producta/us* Johnson as *E. lanceolata*					

Alasmidonta undulata, Triangle Floater

The first known NFSR record of *A. undulata* is a specimen collected by Ortmann in 1912 from Broadway (CMNH #61.5932). Presumably, this is the record cited by Ortmann (1919), Johnson (1970), and Clarke (1981). There is a 1938 collection from Passage Creek by J. P. E. Morrison (2 mi SW of Seven Fountains, NMNH #529660).

More recently within the NFSR drainage, DCR-DNH reported a few relict shells from Chapman Landing in 1995 (Roble, 1998), and Johnson & Neves (2004) reported one shell from Rt. 667, just east of Woodstock in 2004. The last known live specimens were observed by DCR-DNH in Smith Creek in 1990 (Rt. 620 and Mt. Airy) and 1991 (U.S. Rt. 211). Eleven additional surveys in 1990 (DCR-DNH field surveys), 1994 (VDGIF, 2009), 1995 (Roble, 1998; Winston, 1995), 1996 (Winston, 1996), 2005 (The Catena Group, 2006; VDGIF, 2009), and 2006 (VDGIF, 2009) along Smith Creek, including U.S. Rt. 211, found only shell material at eight locations (Table 2). There is no evidence that this species has been found in other tributaries to the NFSR.

In the SFSR drainage, *A. undulata* is recorded from the mainstem at Elkton based on a 1912 collection by Ortmann (CMNH #61.5931; Ortmann, 1919; Johnson, 1970; Clarke, 1981). Ortmann (1919) and Johnson (1970) also cite a 1912 collection (by Ortmann) from the South River, a main tributary to the SFSR, at Waynesboro (CMNH #61.5925). Material collected on 8 September 1968 by W. J. Clench and D. H. Stansbery from Christians Creek (a tributary to the Middle River) at Brand (ca. 4 mi SE Staunton) is housed at MCZ (#266575) and OSUM (#20528).

More recent observations of *A. undulata* have been made in the SFSR drainage (Table 2). Live individuals were observed in Christians Creek at Rt. 831 (Neves, 2003) and the South River downstream of Rt. 657 (DCR-DNH 2000 survey; only shells were found in the same area during a 2007 survey by DCR-DNH). Single shells were reported from both the South River at Rt. 652 (Neves, 2003) and the Middle River SW of Spring Hill (B. Watson, pers. comm.). We are not aware of any recent mussel surveys in the North River.

Alasmidonta undulata was also collected historically from the Shenandoah River mainstem in Virginia between U.S. Rt. 17 and VA Rt. 7 in Clarke County (NMNH #515742 [collector/year: Bartsch/1934]). It is also documented from the Shenandoah River in West Virginia (ANSP #115148 [Fowler/1916] and #365839 [collector unknown/pre-1890]; CMNH #61.5379 [Ortmann/1911]; Ortmann, 1919; Johnson, 1970; Clarke, 1981).

Alasmidonta varicosa, Brook Floater

The first dated collection of *A. varicosa* in the NFSR was obtained "East of Woodstock" in 1957 by J. P. E. Morrison and J. Rosewater (MCZ #216721; same collection presumably cited by Johnson [1970] and Clarke [1981]). Morrison collected *A. varicosa* at the same location in 1963 (NMNH #791515). Three specimens were collected in 1979 "on 5th bend of the 7 bends, about 3 mi. E of Woodstock" (OSUM #45513, collector unknown). Material collected in 1968 by W. J. Clench and D. H. Stansbery from NFSR at VA Rt. 55, 2 mi SE of Strasburg is housed at MCZ (#266346) and OSUM (#20522). Three live specimens were also collected at this site in 1984 by A. Gerberich et al. (R. J. Neves, pers. comm.; disposition of specimens unknown). In 1970, the limnologist E. W. Surber collected *A. varicosa* in NFSR at Rt. 663 (NE of Woodstock) (NMNH #756713). Ortmann collected *A. varicosa* in 1912 at both the SFSR at Elkton (CMNH #61.5935) and the South River at Waynesboro (CMNH #61.5934) (Ortmann, 1919). Johnson (1970) cited the MCZ specimen (#103869) collected by Clench in 1934 from the SFSR at Riverton. ANSP has specimens of *A. varicosa* from three sites (Table 1) along the SFSR between Compton and Limeton (ANSP #390194-96 [all R. Dillon/1976-80], catalogued as *A. marginata*).

We found no evidence of live *A. varicosa* being documented during surveys conducted from 1990-2007 in the NFSR or SFSR drainages (Table 2). Fresh dead specimens were observed on the NFSR at Rt. 600 (DNH field survey, 27 June 1990) and VA Rt. 55 (DNH field survey 26 June 1990, "fresh dead of all ages"). Shells are reported from NFSR for 18 of 20 sampling events at 11 unique locations downstream of and including river mile 52.7 (near Chapman Landing). There is one shell record from Cedar Creek (ca. 0.8 miles from the confluence with NFSR; Neves, 2003) and from eight locations along Smith Creek (Winston, 1996; Roble, 1998; The Catena Group, 2006; VDGIF, 2009).

Reports of *A. varicosa* shells in the SFSR drainage are limited to the South River at Rt. 658 (Neves, 2003) and the SFSR mainstem at Andy Guest/Shenandoah River State Park (1993 DCR-DNH survey; n = 1).

Alasmidonta varicosa was also collected from the Shenandoah River mainstem in Virginia between U.S. Rt. 17 and VA Rt. 7 in Clarke County (NMNH #515741 [George Washington University/1934]). It was also documented from the mainstem in West Virginia (ANSP #41054 [Tryon/no date (probably ca. 1860)]; ANSP #115149 [Fowler/1916]; CMNH #61.5387 [Ortmann/1911]; CMNH #70784 and UMMZ #130185 [both Richmond/1937]; Ortmann, 1919).

Elliptio complanata, Eastern Elliptio

Ortmann (1919) reported *E. complanata* (as *E. violaceus*) from Broadway (ca. NFSR mile 86; CMNH #61.5897). Four other NFSR sites are documented by museum specimens or literature references: Mt. Jackson (UMMZ #44985 [Hobbs/1928]), east of Woodstock (MCZ #216719 [Morrison & Rosewater/1957]; Johnson, 1970), the 5th of 7 bends, ca. 3 mi E of Woodstock (OSUM #45514 [collector unknown/ 1979]), and the VA Rt. 55 bridge, 2 mi SE of Strasburg (MCZ #266269 and OSUM #20525 [both Clench & Stansbery/1968]; NMNH #837327 [no data]). There is one specimen (UMMZ #246060 [Wood/1950]) from the NFSR at Riverton, Virginia, which is catalogued as *E. dilatata*, an Interior Basin species (its range includes southwestern Virginia), but presumably it is referable to *E. complanata* and thus has been included with records of this species in Table 1. There is one historical record of *E. complanata* from Passage Creek, a tributary to the NFSR, from 2 mi SW of Seven Fountains (Johnson, 1970 cites USNM = NMNH, but this record is lacking from the online NMNH database).

More recent surveys (Table 2) recovered shell material from NFSR beginning at river mile 70.8 (Rt. 720, S of Mt. Jackson) downstream through Passage Creek (river mile 5). Live *E. complanata* were observed at 12 of 13 locations between Woodstock and Passage Creek (Roble, 1998; Neves, 2003; Johnson & Neves, 2004). Live specimens were also recently reported for four of ten surveys conducted in Smith Creek during 1990-91 (DCR-DNH field surveys) and 1996 (Winston, 1996). Shell material was observed at all ten survey locations (Winston, 1996; Roble, 1998; The Catena Group, 2006). Live *E. complanata* were observed in good numbers at four locations in Passage Creek in 2007 (Ostby et al., 2008). Shell material only was observed in Cedar Creek (Roble, 1998; Neves, 2003).

Elliptio complanata was collected historically from at least seven locations on the SFSR: Elkton (CMNH #61.5896 [Ortmann/1912]), "below Luray" (ANSP #389143 [Dillon/1974]), Rt. 613 near Bentonville (ANSP #389144 [Dillon/1976] and #353170 [Dillon/ 1980]; NMNH #837332 [no data]), which may be the same locality as collections from "about 8 miles SW of Front Royal" made by Morrison and Rosso (1954; both NMNH #853600 and UMMZ #216399), Hazard Mill Recreation Area, 1.5 mi W of Bentonville (ANSP #389145 [Dillon/1976]), 2 mi W of Compton (= 3 mi below Goods Falls) (ANSP #389148 [Dillon/1976]), 2 mi NW of Limeton (ANSP #389141 [Dillon/1976]), and Front Royal (UMMZ #246100 [Wood/1950]). Johnson (1970) reported an MCZ record from the North River at Weyers Cave, but an online search of the MCZ database did not confirm this. Ortmann (1919) reported his 1912 South River collection (as *E. violaceus*) from Waynesboro (CMNH #61.5887); there is also a more recent collection from this site (ANSP #390106 [Worsely/1977]).

There are several museum records from the Shenandoah River mainstem in Virginia (ANSP #42815 [Tryon/no date (probably ca. 1860)]; UMMZ #246075 [collector unknown/1946]) and at Harpers Ferry, West Virginia (UMMZ #94128 [Allen/no date]); CMNH #61.5353 [Ortmann/1911]; CMNH #70785 and UMMZ #130184 [both Richmond/1937]).

Only one live *E. complanata* has been reported during recent surveys in the SFSR. Beaty & Neves (1998) observed this species at the Rt. 613 crossing near Bentonville. Two live individuals were observed by DCR-DNH in the South River downstream of Rt. 657 and shells were collected from Christians Creek (Neves, 2003).

Elliptio fisheriana, Northern Lance

The taxonomy of Atlantic Slope *Elliptio* species is not resolved and in need of genetic study (NatureServe, 2009). Johnson (1970) lumped many nominal lanceolate species into *Elliptio lanceolata*, including *E. fisheriana* and *E. producta*. For the purposes of this report, a narrower definition is used where *E. lanceolata* does not occur north of the Rappahannock River drainage in Virginia (Alderman, 2003; Bogan et al., 2009). The name *Elliptio producta* is reported in early museum collections (Table 1), and *E. angustata, E. producta,* and *E. fisheriana* were used inter-changeably by various biologists in the 1990s and early 2000s to apply to the same taxon (Table 2). According to recent genetic research on lanceolate *Elliptio* species in Virginia, "all black, shiny black, yellowish green with rays lanceolate *Elliptio*s from Virginia with and without a sharp posterior ridge and with straight or curved margins are all considered *Elliptio fisheriana* at this time pending addition of other topotypic lanceolate taxa from South Carolina and Georgia" (Bogan et al., 2009). Therefore, all previous records of lanceolate *Elliptio* specimens and field observations from the Shenandoah River drainage are treated as *E. fisheriana* in this report. However, the records are presented in the tables and appendices using the original determinations.

Elliptio fisheriana is known from two NFSR sites based on museum collections: 5th of 7 bends, ca. 3 mi E of Woodstock (OSUM #45515 [collector unknown/ 1979], catalogued as *E. producta*) and VA Rt. 55, 2 mi SE of Strasburg (NMNH #837328 [no data], catalogued as *E. angustatus*; OSUM #20524 [Clench &

Table 2. Summary of mussel surveys conducted in the North Fork Shenandoah River (NFSR) and South Fork Shenandoah River (SFSR) drainages between 1990 and 2007. Tributaries to NFSR and SFSR are listed in upstream to downstream order. All river miles are estimated from the mouth. An 'L' or a number (if recorded) indicates that live animals were reported, and precedes an 'S' or a number, which indicates if shell material was reported. Numbers for the exotic Asiatic clam, *Corbicula fluminea*, are not given here. VMNH = Virginia Museum of Natural History. 1 = reported as *Elliptio* sp.; 2 = reported as *Elliptio producta*; 3 = reported as *Elliptio lanceolata;* 4 = reported as *Lampsilis* sp. * = No mussels (live or shell) observed.

River	Location	River Mile	Year	*Alasmidonta undulata*	*Alasmidonta varicosa*	*Elliptio complanata*	*Elliptio fisheriana*	*Lampsilis cariosa*	*Lampsilis ovata*	*Lasmigona subviridis*	*Strophitus undulatus*	*Corbicula fluminea*	Reference and Comments
North Fork Shenandoah River Drainage													
NFSR	VA Rt. 259	88.7	1990*										DNH field survey
NFSR	Rt. 617	86.3	1990*										DNH field survey
NFSR	Rt. 953/617	78.0	1990									L/S	DNH field survey
NFSR	Rt. 767	73.5	1995									L/S	Roble, 1998
NFSR	Rt. 720	70.8	1990			0/S							DNH field survey
NFSR	US Rt. 11	69.8	2002									L/S	Neves, 2003
NFSR	Off Rt. 698	67.1	2002			0/5						L/S	DNH field survey
NFSR	Off Rt. 698	67.1	2002	0/S	0/S	0/3							Catena Group, 2007
NFSR	Rt. 675	57.5	2002									L/S	DNH field survey
NFSR	Rt. 672	52.7	1995	0/S	0/S	0/S	0/S					L/S	Roble, 1998
NFSR	Chapman Dam	48.5	1990			-/3	-/1						VMNH collection
NFSR	Rt. 667	45.2	2004	0/1	0/2	6/S	0/3		0/1			L/S	Johnson & Neves, 2004
NFSR	Rt. 758	41.7	1990		0/S	0/S[1]		0/S		0/S		L/S	DNH field survey
NFSR	Rt. 758	41.7	2003		0/1	0/8					0/2	L/S	Neves, 2003
NFSR	Rt. 663	36.5	1990			0/S	0/1[2]	0/1				L/S	DNH field survey
NFSR	Rt. 663	36.5	2003		0/1	0/6		0/2[4]				L/S	Neves, 2003
NFSR	0.5 mi downstream Pugh Run	36.2	1992			-/3	-/1						VMNH collection
NFSR	Farmer's Mill near Rt. 661	32.2	1990		0/34	4/25+	1/9[2]	0/5			0/1	L/S	DNH, VMNH, Hoffman, 2001
NFSR	Rt. 600	28.4	1990		0/S	L/S	1/S[2]	0/5		1/S	0/1	L/S	DNH field survey
NFSR	Rt. 600	28.4	1995		0/4	0/200	0/30+	0/1			0/2	L/S	Roble, 1998
NFSR	Rt. 600	28.4	2002		0/1	3/S	0/S[3]					L/S	Neves, 2003
NFSR	Rt. 744	17.0	2002*										Hartman, 2002
NFSR	Rt. 744	17.0	2007		0/3	0/S[1]						L/S	Hartman, 2007
NFSR	Rt. 648	12.6	1990		0/S	L/S	0/S[2]	0/4		0/4	0/1	L/S	DNH field survey
NFSR	Rt. 648	12.6	1995		0/S	18/S	0/S[2]					0/S	DNH field survey
NFSR	Rt. 648	12.6	2002		0/2	19/S	0/S[3]	0/1		0/1		L/S	Neves, 2003
NFSR	VA Rt. 55	10.1	ca. 1990			-/6							VMNH collection
NFSR	VA Rt. 55	10.1	1990		0/50	L/10+	0/3[2]	0/S		0/12	0/1	L/S	DNH, VMNH
NFSR	VA Rt. 55	10.1	1995		0/S	14/10+		0/S			0/S	L/S	Roble, 1998
NFSR	VA Rt. 55	10.1	2002		0/2	1/S	0/S[3]					L/S	Neves, 2003
NFSR	Rt. 610	5.2	1990		0/S	L/S	0/S[2]	0/S		0/S	0/S	L/S	DNH field survey
NFSR	Off Rt. 612	5.0	2002		0/1	3/S	0/1[3]				0/1	L/S	Neves, 2003
Holman's Creek	VA Rt. 42	5.2	2005*										Catena Group, 2006
Smith Creek	Downstream Rt. 811	27.8	2006								4/0		VDGIF, 2009
Smith	Rt. 811	27.0	1995	0/3							14/8		Winston, 1995b
Smith	Rt. 793	17.2	1995	0/S	0/1	0/S						L/S	Roble, 1998
Smith	Off Rt. 620	16.8	2005	0/5	0/1						0/1		VDGIF, 2009

Table 2 (continued).

River	Location	River Mile	Year	*Alasmidonta undulata*	*Alasmidonta varicosa*	*Elliptio complanata*	*Elliptio fisheriana*	*Lampsilis cariosa*	*Lampsilis ovata*	*Lasmigona subviridis*	*Strophitus undulatus*	*Corbicula fluminea*	Reference and Comments
Smith	Rt. 794	16.1	1995	0/1		0/10						L/S	Roble, 1998
Smith	Rt. 620	15.9	2005	0/S	0/S	0/S					0/S		Catena Group, 2006
Smith	Rt. 823	14.1	1990		-/2	-/3							VMNH collection
Smith	US Rt. 211	11.3	1991	L/S	0/2	L/S						L/S	DNH field survey
Smith	US Rt. 211	11.3	1995	0/S	0/S	0/S	0/S					L/S	Roble, 1998
Smith	Rt. 620	6.3	1995	0/1		0/S						0/S	Roble, 1998
Smith	Rt. 620	5.5	1996	0/5	0/5	7/1+					0/1		Winston, 1996
Smith	Rt. 620	4.4	1990	1/S	0/S	3/S					1/3	L/S	DNH, VMNH
Smith	Rt. 730	1.4	1990			1/-						L/S	DNH field survey
Smith	Rt. 730	1.4	1994		0/7						0/1		VDGIF, 2009
Smith	Private road	0.6	1990	1/-	0/S	1/-					0/S	L/S	DNH field survey
Smith	Private road	0.1	1994								0/1		VDGIF, 2009
Mill Creek	Rt. 612	9.5	2005*										Catena Group, 2006
Straight Run	Rt. 724	-	2005*										Catena Group, 2006
Stony Creek	Rt. 723	19.0	2005										2 live *Pyganodon cataracta*; Catena Group, 2006
Stony	Rt. 710	3.8	1995*										Winston, 1995a
Stony	Off Rt. 675	2.0										0/S	Neves, 2003
Swover Creek	Rt. 691	-	1995*										Winston, 1995a
Cedar Creek	Rt. 628	13.3	2003									L/S	Neves, 2003
Cedar	Rt. 622	8.0	1990*										DNH field survey
Cedar	US Rt. 11	2.6	1996			0/1						0/S	Roble, 1998
Cedar	Rt. 635	0.8	1990*										DNH field survey
Cedar	Rt. 635	0.8	2003		0/1	0/43						L/S	Neves, 2003
Passage Creek	Rt. 730	30.0	2007*										Ostby et al., 2008
Passage	Rt. 775	22.2	2007									L/S	Ostby et al., 2008
Passage	Seven Fountains Rd	16.5	2007			6/0						L/S	Ostby et al., 2008
Passage	Rt. 772	13.1	2007			14/0						L/S	Ostby et al., 2008
Passage	Off Rt. 678	8.0	2007			81/0						L/S	Ostby et al., 2008
Passage	Elizabeth Furnace	6.7	1996			0/1						-/S	DNH field survey
Passage	Elizabeth Furnace	6.5	2007			31/0						L/S	Ostby et al., 2008
Passage	VA Rt. 55	1.3	2007									L/S	Ostby et al., 2008
Passage	Rt. 610	0.1	2007									L/S	Ostby et al., 2008
South Fork Shenandoah River Drainage													
Middle River	Rt. 742	35.5	2005	0/1									B. Watson, pers. comm.
Christians Creek	US Rt. 340	22.8	2003									0/S	Neves, 2003
Christians	Rt. 831	21.3	2003	8/0		0/11					2/0	0/S	Neves, 2003
South River	Rt. 658	43.5	2003		0/1						0/1	0/0	Neves, 2003
South	Rt. 652	42.2	2003	0/1								0/S	Neves, 2003

Table 2 (continued).

River	Location	River Mile	Year	*Alasmidonta undulata*	*Alasmidonta varicosa*	*Elliptio complanata*	*Elliptio fisheriana*	*Lampsilis cariosa*	*Lampsilis ovata*	*Lasmigona subviridis*	*Strophitus undulatus*	*Corbicula fluminea*	Reference and Comments
South Fork Shenandoah River Drainage													
South River	Rt. 657 (Cowbane Prairie Nat. Area Preserve)	39.8	2000	25-30/ 5-6							100+/ 10+	L/S	DNH field survey
South	Rt. 657 (Cowbane Prairie NAP)	39.8	2007	0/15		2/0					1/20+	L/S	DNH field survey
South	Shenandoah Wetland Mitigation Bank site	39.1	2003									L/S	DNH field survey
South	Rt. 664	29.8	1990									L/S	DNH field survey
South	Rt. 664	29.8	2003			0/7						L/S	Neves, 2003
South	Waynesboro	25.9	2003									L/S	Neves, 2003
Back Creek	Rt. 624	-	2003									0/S	Neves, 2003
SFSR	Rt. 675	44.1	1990			0/S							DNH field survey
SFSR	Rt. 613	18.2	1998			1/35							Beaty & Neves, 1998
SFSR	Rt. 613	18.2	2002			0/S							Neves, 2003
SFSR	Shen. River State Park	15	1993		0/1	0/S		0/S					DNH field survey, Roble, 1998
SFSR	Shen. River State Park	15	1995			0/100's		0/S					DNH field survey, Roble, 1998
Indian Hollow	Rt. 613	-	1998*										Beaty & Neves, 1998

Stansbery/1968], catalogued as *E. producta*; MCZ #266270 [Clench & Stansbery/1968], catalogued as *E. lanceolata*). Johnson (1970) reported this species (as *E. lanceolata*) from 'E Woodstock' presumably based on material in the MCZ (#216720 [Morrison & Rosewater/ 1957], catalogued as *E. productus*). The last known records of live *E. fisheriana* in the NFSR are of one individual each at two sites observed in 1990 during DCR-DNH field surveys (both recorded in field notes as *E. producta*). Shell material of *E. fisheriana* (identified variously as *E. producta*, *E. fisheriana*, and *E. lanceolata*) has been found from Chapman Landing (Rt. 672) to Passage Creek. There is only one record of shell material of *E. fisheriana* in Smith Creek (Roble, 1998), and no evidence of its presence in any other NFSR tributary. There are no historical or recent records of *E. fisheriana* from the SFSR. It is unknown if this species is absent from this drainage, or if it has been overlooked due to infrequent surveys.

There are historical records of a lanceolate *Elliptio* species from the Shenandoah River mainstem in Virginia and West Virginia that are variously catalogued as *E. fisherianus* (ANSP #41562 [Tryon/no date (probably ca. 1860)]; reported as *E. cupreus* by Ortmann, 1919), *E. lanceolata* (Johnson, 1970; ANSP #365823 [collector unknown/pre-1890]), *E. producta/ productus* (ANSP #127138 [collector unknown/pre-1918]), CMNH #61.12360 [Ortmann/1911]; UMMZ #94547 [Hartman/no date (probably ca. 1870)]), and *E. shepardiana* (UMMZ #22810 [Tryon/no date (probably ca. 1860)]). Presumably, all of these specimens are referable to *E. fisheriana*.

Lampsilis cariosa, Yellow Lampmussel
and *Lampsilis ovata*, Pocketbook

Johnson (1970) reported that *Lampsilis ovata* was accidentally introduced into the Shenandoah River system in 1889 as larvae on bass and other fishes transplanted from the Interior Basin and St. Lawrence

River system where *L. ovata* naturally occurs. Morrison (1972) believed that *L. cariosa* did not occur in the Potomac River basin significantly above the Fall Line, and that the specimens from the Shenandoah were *L. ovata*. *Lampsilis cariosa,* which is native to Atlantic Slope drainages (Johnson, 1970), can be distinguished from *L. ovata* by the sharp posterior ridge and dull olivaceous tint of the shell, often completely rayed in the latter species. *Lampsilis cariosa* usually has a distinct bright yellow, glossy periostracum, with rays usually confined to the posterior slope (Johnson, 1970). Relict shell material may be difficult to distinguish. Records under both names are provided here, but all may in fact refer to *L. ovata*.

Museum records of *Lampsilis* species (MCZ specimens catalogued as *L. ovata ventricosa*) are available from three sites on the NFSR: east of Woodstock (MCZ #216708 [Morrison & Rosewater/ 1957], Farmer's Mill near Rt. 661, 2 mi S Mauertown (VMNH #329 [Lipford/1990], two relict valves reported as *L. cariosa* by Hoffman, 2001), and VA Rt. 55, 2 mi SE of Strasburg (MCZ #266274 and OSUM #20526 [both Clench & Stansbery/1968], latter catalogued as *L. cardium*; NMNH #837329 [no data], catalogued as *L. ventricosa*). Only one recent survey on the NFSR (Rt. 667) identified shell material as *L. ovata* (Johnson & Neves, 2004). There are museum records for *L. ovata* from four sites on the SFSR: below Luray (ANSP #389202 [Dillon/1974], Rt. 613 near Bentonville (NMNH #83733 [no data]), Hazard Mill Recreation Area, 1.5 mi W of Bentonville (ANSP #389207 [Dillon/1976], and 2 mi W of Compton (ANSP #389211 [Dillon/1976]). We are not aware of any recent survey observations of *L. ovata* in the SFSR drainage. A collection from the SFSR 2 mi NW of Limeton is catalogued as *L. cardium* (ANSP #389214 [Dillon/1976]). Online database searches yielded several museum records of *L. ovata* (NMNH specimens catalogued as *L. ventricosa*) from the Shenandoah River mainstem in Virginia: NMNH #466824-25 [Morrison/ 1936]; NMNH #515740 [no data]; MCZ #192906 and UMMZ #247324 [both Athearn & Athearn/1950]; UMMZ #246030 [no data]).

Lampsilis cariosa is not recorded from the NFSR prior to Johnson's 1970 publication, and there is only one record from the SFSR (NMNH #853596 [Morrison & Rosso/1954]). Surveys in the 1990s by DCR-DNH (unpublished field notes) recorded *L. cariosa* from seven locations in the NFSR and Neves (2003) reported *L. cariosa* during a 2002 survey at one of these same locations. DCR-DNH reported *L. cariosa* shells in the SFSR at Shenandoah River Raymond R. "Andy" Guest, Jr. State Park in 1995. No live *L. cariosa* were found in either drainage.

Lasmigona subviridis, Green Floater

Lasmigona subviridis is known from three museum collections obtained at the VA Rt. 55 crossing of the NFSR, 2 mi SE of Strasburg: MCZ #266275 and OSUM #20523 [both Clench & Stansbery/1968]; NMNH #837331 [no data]; Clarke (1981). There are museum records of *L. subviridis* from the SFSR at Elkton (CMNH #61.5911 [Ortmann/1912]; Ortmann, 1919; Johnson, 1970) the U.S. Rt. 211 bridge near Luray (NMNH #837335 [no data]), Rt. 613 near Bentonville (ANSP #390203 [Dillon/1976]), and 2 mi W of Compton (ANSP #390204 [Dillon/1976]). A collection record for "Page County" (UMMZ #104151 [Bryant/no date]) is probably from the vicinity of Luray. Museum records for the Shenandoah River mainstem in Virginia exist for Front Royal (NMNH #251566 [Cooke/no date]) and between U.S. Rt. 17 and VA Rt. 7 in Clarke County (NMNH #427267 [Bartsch/ 1934]), and there is at least one collection from Harpers Ferry, West Virginia (CMNH #61.5361 [Ortmann/ 1911]).

One live *L. subviridis* was observed by DCR-DNH in 1990 at the Rt. 600 bridge crossing of the NFSR (ca. river mile 28.4). Otherwise, only shell material was observed at five locations between Burnshire Dam (Rt. 758, ca. river mile 41.7) and the mouth of Passage Creek. This species has not been documented from any NFSR tributaries. There are no recent survey observations of *L. subviridis* from the SFSR.

Strophitus undulatus, Creeper

There are four historical records of *Strophitus undulatus* from the NFSR: Broadway (CMNH #61.5947 [Ortmann/1912]; Ortmann, 1919), east of Woodstock (MCZ #216718 [Morrison & Rosewater/ 1957]; Johnson, 1970), 5th of 7 bends, ca. 3 mi E of Woodstock (OSUM #45512 [collector unknown/ 1979]), and VA Rt. 55, 2 mi NE of Strasburg (NMMH #837330 [no data]). Museum records of *S. undulatus* from the SFSR drainage are available from Elkton (CMNH #61.5946 [Ortmann/1912]; Ortmann, 1919; Johnson, 1970), below Luray (ANSP #390166 [Dillon/ 1974], Rt. 613 near Bentonville (ANSP #403506 [Dillon/1980]; NMNH #837334 [no data]), ca. 8 miles SW of Front Royal (NMNH #853597 [Morrison & Rosso/1954]), and 2 mi W of Compton (ANSP #390165 [Dillon/1976]). A Page County record (UMMZ #74651 [Bryant/no date]) is probably from the vicinity of Luray. There are also records from the South River at Waynesboro (CMNH #61.5937 [Ortmann/ 1912]; Ortmann, 1919; Johnson, 1970) and Christians Creek at Brand (MCZ #266671 and OSUM #20527

[both Clench & Stansbery/1968]). Museum collections exist for the Shenandoah River mainstem between U.S. Rt. 17 and VA Rt. 7 in Clarke County, Virginia (NMNH #515743 [Bartsch/no date]) and from Harpers Ferry, West Virginia (ANSP #115150 [Fowler/1916]).

Recent surveys documented *S. undulatus* at seven locations along the NFSR (shells only) and at eight sites in Smith Creek. Live individuals were observed in Smith Creek in 1990 (DCR-DNH; n = 1), 1995 (Winston, 1995; n = 14), and 2006 (VDGIF, 2009; n = 4, site just upstream of the Winston record). There are no recent observations of *S. undulatus* in the mainstem of the SFSR, but there have been reports of live individuals in Christians Creek (Rt. 831; Neves, 2003) and in the South River (downstream of Rt. 657; DCR-DNH field surveys in 2000 and 2007).

FIELD SURVEY METHODS

We evaluated existing survey data, including museum specimens, published literature, unpublished reports, and unpublished field notes, to determine the locations of previous survey sites and potential areas of mussel species of conservation concern. Recent information on physical attributes and fish communities of the NFSR (Krstolic et al., 2006) and SFSR (J. L. Krstolic, pers. comm.) were also considered in the site selection process. In addition, *de novo* survey sites were selected by identifying reaches of the NFSR and selected tributaries (e.g., Cedar, Passage, and Smith creeks) and the SFSR and selected tributaries (e.g., North, Middle, and South rivers, and Christians Creek) that had not been previously surveyed. Field surveys took place between 28 July 2008 and 7 October 2009.

Survey crews used snorkel and/or viewscope techniques to locate live mussels and shell material. Muskrat middens were examined for discarded shell material. Data were recorded on physical attributes such as stream width, substrate types, water temperature, turbidity, relative degree of sedimentation, and weather conditions, as well as length of survey (time and distance) and conservation concerns.

Due to the difficulty in distinguishing *Lampsilis cariosa* from *L. ovata* based solely on relict shell material, the designation *Lampsilis* sp. is used here, although literature and museum records suggest that only *L. ovata* occurs in the study area. Live or fresh material, if found during this study, would have been determined to species.

Initially, surveys focused on the NFSR and its tributaries; however, as work progressed, few live mussels were found and thus inventory efforts were expanded to include the SFSR drainage. In particular, sections of the South River upstream of Waynesboro that may have escaped historical chemical pollution (Carter, 1977) were targeted for survey, as were the Middle and North Rivers, which had minimal available survey data. Surveys were also conducted in the SFSR mainstem. The locations of freshwater mussel surveys conducted by DCR-DNH staff during 2008-2009 in the NFSR and SFSR drainages are shown in Figs. 3 and 4, respectively.

RESULTS

During 2008-2009, we conducted 87 surveys at 84 unique sites (Table 3). Only five of 26 locations on the NFSR yielded observations of live native mussels, all of which were identified as *Elliptio complanata* (n = 26), a common species throughout the Atlantic Slope. All five locations are downstream of Woodstock, Shenandoah County, Virginia. Live *E. complanata* (n = 5) also were observed at one of eight survey sites in Smith Creek, a tributary to the NFSR. Only two live *E. complanata* were found at seven sampling sites along the SFSR mainstem. Live *Alasmidonta undulata*, *Strophitus undulatus*, and *E. complanata* were found in the South River, a tributary to the SFSR. These observations include high numbers of *A. undulata* (25-30 and 77 in 2000 and 2009, respectively) and *S. undulatus* (100-105 and 104 in 2000 and 2009, respectively) occurring syntopically with moderate numbers of *E. complanata* (21 in 2009) below Rt. 657 along Cowbane Prairie Natural Area Preserve and extending into the adjacent Shenandoah Wetland Mitigation Bank property. One fresh dead specimen of *A. undulata* was found in Christians Creek.

Shell material of six mussel species was identified from the NFSR drainage: *A. undulata*, *A. varicosa*, *E. complanata*, *E. fisheriana*, *Lampsilis* sp., and *S. undulatus*. Shells of all of these species except *E. fisheriana* also were found in the SFSR drainage. No shells of *L. subviridis* (or *P. cataracta*) were found in either drainage.

DISCUSSION

Mussel Diversity and Distribution

Compared to the species-rich rivers of the Tennessee drainage (e.g., Clinch River: 60 species, Ortmann, 1918, Ahlstedt, 1991; Copper Creek: 25 species, Hanlon et al., 2009; Powell River: 41 species, Ortmann, 1918, Wolcott & Neves, 1994), the mussel diversity of Atlantic Slope rivers tends to be much lower (e.g., Rappahannock River system: 8 species, Ortmann, 1913, Johnson, 1970; Pamunkey River system: 10 species, Riddick, 1973, Blood & Riddick,

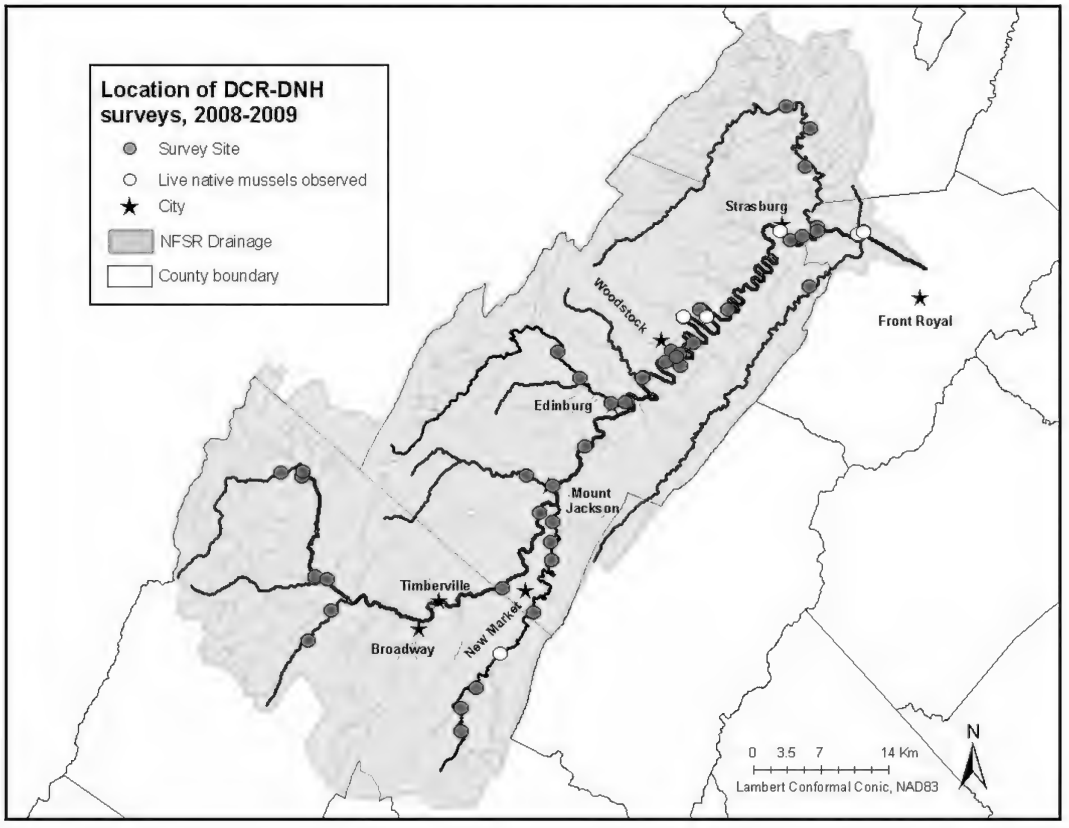

Fig. 3. DCR-DNH freshwater mussel survey locations in the North Fork Shenandoah River drainage, 2008-2009.

1974; Chowan River system [includes Blackwater, Nottoway, and Meherrin rivers in Virginia]: ca. 20 species, Johnson, 1970, Fuller, 1975, Alderman, 1995). Likewise, the historical mussel fauna of the Shenandoah River drainage in Virginia was characterized by low diversity. Only eight species have been documented from the NFSR and just seven from the SFSR, including the more lentic species, *Pyganodon cataracta*. Taylor (1985) documented the same eight species from the headwaters of the Potomac River in West Virginia. Johnson (1970) reported only five additional species from the entire Potomac drainage (*Alasmidonta heterodon*, *Anodonta implicata*, *Leptodea ochracea*, *Lampsilis radiata*, and *Ligumia nasuta*) and noted both *Lampsilis cariosa* and *Lampsilis ovata* (see species accounts above). Based on the results of the current study, the historically low diversity of the NFSR and SFSR may have declined to only one remaining species (*E. complanata*) confirmed from the NFSR and three species (*A. undulata*, *E. complanata*, and *S. undulatus*) confirmed as extant in the SFSR. Other species may persist in either or both drainages, but in such low numbers that they were not detected during this study. The lack of live or shell material of *L. subviridis* during our surveys may indicate that this species has been extirpated from the Shenandoah River drainage (last live specimen found in 1990).

In addition to an apparent reduction in the number of surviving species, there also seems to be a reduced distribution of the mussel fauna in the NFSR and SFSR. Museum records indicate that mussels once occurred in the NFSR upstream as far as Broadway in Rockingham County, Virginia (ca. river mile 86; Ortmann, 1919) (Table 1). Recent surveys (1990-2007) reported live mussels (mostly *E. complanata*, but also *E. fisheriana* and *L. subviridis*) at most sampling locations between NFSR river miles 0 and 45.2, but in 2008-2009, only live *E. complanata* were found at five (all between river miles 4.5 and 36.5) of 26 survey sites. Live mussels were found at several sites in Smith Creek during past surveys (DCR-DNH field survey, 1990; Winston, 1995; VDGIF, 2009), but at only one of our eight survey sites. Ostby et al. (2008) also reported live *E. complanata* from several sites along Passage Creek in 2007.

Museum records reveal that mussels were collected historically from three headwater tributaries of the SFSR (North River, South River, and Christians Creek) (Table 1) and from the mainstem extending from Elkton (river mile 80.4) to Front Royal (river mile 0). Recent surveys (Table 2) and the current survey (Table 3)

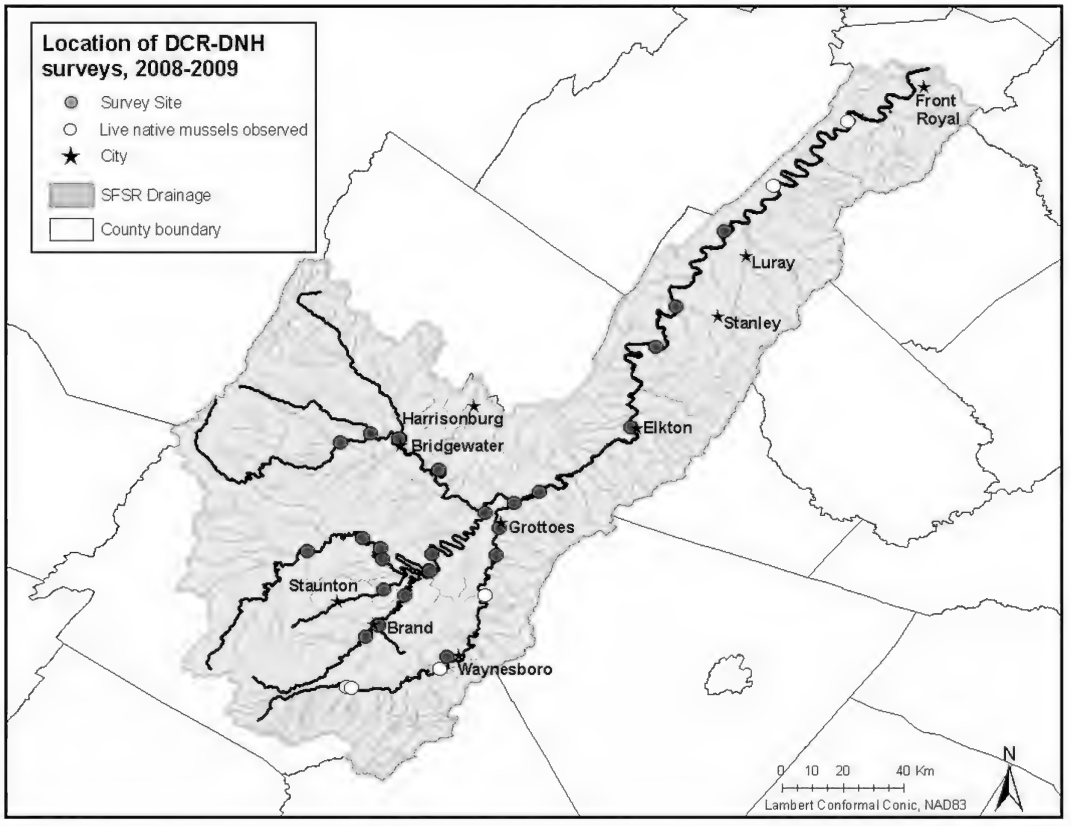

Fig. 4. DCR-DNH freshwater mussel survey locations in the South Fork Shenandoah River drainage, 2008-2009.

documented live native mussels in two headwater tributaries (South River and Christians Creek), but only three live *E. complanata* were observed in the SFSR mainstem (one each at river miles 15.0, 18.2, and 34.5).

The pattern of mussel populations becoming scarcer in the mainstem of a river and viable populations being limited to its tributaries is documented in other areas (Alderman, 1994; Chazal, 2005). This fragmented distribution may increase the risk of a mussel population becoming genetically isolated or extirpated due to localized events such as drought, chemical spills, or impounding.

Habitat Conditions and Threats

The NFSR and SFSR both flow through predominantly agricultural areas, with livestock, poultry, and crops (mostly corn) common and contributing to non-point source pollution. Twelve tributaries to NFSR have been identified by the Virginia Department of Environmental Quality (VDEQ) as impaired waters (VDEQ, 2008b). The NFSR mainstem is classified as impaired in two sections: 1) between Turley Creek and Holmans Creek, primarily due to non-point source pollution and the presence of fecal coliforms and *Escherichia coli*; and 2) from the Passage Creek confluence downstream to the confluence of the NFSR and SFSR (beginning of Shenandoah River mainstem), due to high mercury loads. Large portions of all three major tributaries to the SFSR (North, Middle, and South rivers) are listed as impaired waters, as is the entire SFSR (VDEQ, 2008b). Causes of the impaired classification include high mercury levels, the presence of fecal coliforms and *E. coli*, and poor benthic macroinvertebrate ratings (VDEQ, 2008b). Eggleston (2009) estimated that mercury input into the South River, largely emanating from contaminated floodplain sediments, needs to be reduced by 98.9% (from 189 to 2 kg per year) to prevent fish tissue methyl mercury concentrations from rising above acceptable levels for human consumption. Similar reductions are estimated for the SFSR and the Shenandoah River mainstem.

General observations of the sediments throughout all study reaches indicate that embedded substrates are common. Embedded substrates are problematic for the survival of macroinvertebrates, including mussels, because they reduce the availability of suitable microhabitats in the hyporheic zone (Box & Mossa, 1999; Ostby, 2005). However, it should be noted that embeddedness was not quantified during this study.

Table 3. Summary of mussel surveys conducted in the North Fork Shenandoah River (NFSR) and South Fork Shenandoah River (SFSR) drainages by DCR-DNH in 2008 and 2009. Tributaries to NFSR and SFSR are listed in upstream to downstream order. All river miles are estimated from the mouth of listed river. An 'L' or a number indicates that live animals were observed, and precedes an 'S' or a number, which indicates if shell material was observed. Numbers for the exotic Asiatic clam, *Corbicula fluminea*, are not given here. All *Lampsilis* shells were relict and thus not identified to species (see text for further discussion). No live individuals or shells of *Lasmigona subviridis* (or *Pyganodon cataracta*) were found during the surveys. "7BSP" = the future site of Seven Bends State Park; "NC" = Not Calculated.

River	Location	Date	River Mile	*Alasmidonta undulata*	*Alasmidonta varicosa*	*Elliptio complanata*	*Elliptio fisheriana*	*Lampsilis* sp.	*Strophitus undulatus*	*Corbicula fluminea*	Comments
German	Rt. 826	5-Aug-08	1.4								No mussels
NFSR	Rt. 820	5-Aug-08	103.3								No mussels
NFSR	at "Blue Hole"	5-Aug-08	103.0								No mussels
Little Dry	at NFSR	5-Aug-08	0								No mussels
NFSR	at Little Dry	5-Aug-08	94.9								No mussels
NFSR	Rt. 612	6-Aug-08	92.9								No mussels
Shoemaker	Rt. 612	6-Aug-08	4.9								No mussels
Shoemaker	off Rt. 612	6-Aug-08	1.8								No mussels
NFSR	Rt. 617 (Plains Mill)	6-Aug-08	78.0	0/1		0/1				L/S	Live *Corbicula* only
NFSR	Rt. 720	6-Aug-08	70.8			0/1				L/S	Live *Corbicula* only
NFSR	Rt. 720	9-Oct-08	70.8							L/S	Live *Corbicula* only
Smith	Rt. 811	10-Sep-08	28.0							0/S	No live mussels
Smith	Rt. 717 (E of Lacey Springs)	15-Sep-09	26.2							L/S	Live *Corbicula* only
Smith	Rt. 608 (SE of Mauzy)	15-Sep-09	22.8							L/S	Live *Corbicula* only
Smith	Rt. 796	15-Sep-09	18.8	0/1		5/10-15				L/S	1 live native species
Smith	Rt. 823 (at jct w/ Rt. 620)	15-Sep-09	14.0	0/1		0/7-9				L/S	Live *Corbicula* only
Smith	Rt. 620 (NW of Alpine)	10-Sep-08	6.3	0/1		0/10+			0/3	L/S	Live *Corbicula* only
Smith	Rt. 732/Rt. 620	10-Sep-08	4.4	0/2	0/1	0/20+				L/S	Live *Corbicula* only
Smith	Rt. 730	9-Oct-08	1.4			0/10+				L/S	Live *Corbicula* only
Mill	Rt. 614	25-Aug-08	2.1							0/S	No live mussels
NFSR	Rt. 698 (E of Mt. Jackson)	25-Aug-08	68.0			0/1				L/S	Live *Corbicula* only
NFSR	Rt. 707	9-Sep-08	63.8	0/2	0/2	0/40+				L/S	Live *Corbicula* only
Stony	Rt. 675	25-Aug-08	6.8							L/S	Live *Corbicula* only
Stony	Rt. 682	25-Aug-08	4.5							L/S	Live *Corbicula* only
Stony	Hwy. 11	25-Aug-08	1.3							L/S	Live *Corbicula* only
Stony	at NFSR	9-Oct-08	0							L/S	Live *Corbicula* only
NFSR	at Stony	9-Oct-08	57.5			0/6-7				L/S	Live *Corbicula* only
Narrow Passage	at NFSR	9-Sep-08	0			0/6-7				L/S	Live *Corbicula* only

Table 3 (continued).

River	Location	Date	River Mile	*Alasmidonta undulata*	*Alasmidonta varicosa*	*Elliptio complanata*	*Elliptio fisheriana*	*Lampsilis* sp.	*Strophitus undulatus*	*Corbicula fluminea*	Comments
NFSR	at Narrow Passage Creek	9-Sep-08	52.7							L/S	Live *Corbicula* only
NFSR	Rt. 609	25-Sep-08	47.8		0/1	0/50+	0/20+	0/4-5		L/S	Millions of *Corbicula*
NFSR	7BSP - downstream Rt. 609	7-Oct-08	46.9			0/6		0/1		L/S	Live *Corbicula* only
NFSR	7BSP - Camp Lupton	7-Oct-08	46.0			0/36	0/1	0/1		L/S	Live *Corbicula* only
NFSR	Rt. 667	29-Jul-08	45.2			0/100+	0/5	0/1		L/S	Live *Corbicula* only
NFSR	7BSP - downstream Rt. 667	7-Oct-08	44.8		0/1	0/30-40	0/2			L/S	Live *Corbicula* only
NFSR	Rt. 758 (Burnshire Dam)	25-Sep-08	41.7			0/5	0/1			L/S	Millions of *Corbicula*
NFSR	Rt. 663	28-Jul-08	36.5			0/4-5	0/1			L/S	Live *Corbicula* only
NFSR	Rt. 663	23-Sep-08	36.5		0/1	4/100+	0/10	0/1		L/S	1 live native species
NFSR	off Rt. 661	23-Sep-08	32.2			1/1000's	0/50+	0/3-4	0/2	L/S	1 live native species
NFSR	Rt. 661	29-Jul-08	31.6			0/30	0/2			L/S	Live *Corbicula* only
NFSR	Rt. 600	29-Jul-08	28.4			0/35	0/1			L/S	Live *Corbicula* only
NFSR	downstream Rt. 648	24-Sep-08	12.4		0/2	13/100's	0/100's	0/1	0/1	L/S	1 live native species
NFSR	off Rt. 1201	30-Jul-08	11.5			0/60+	0/2			L/S	Live *Corbicula* only
NFSR	Hwy. 55	24-Sep-08	10.1		0/2-3	0/100's	0/20+	0/2		L/S	Live *Corbicula* only
Cedar	Rt. 606	30-Jul-08	17.3							L/S	Live *Corbicula* only
Cedar	Rt 628 (Stephens Fort)	30-Jul-08	13.3							L/S	Live *Corbicula* only
Cedar	Rt. 622 (Minebank Ford)	30-Jul-08	8.0							L/S	Live *Corbicula* only
Cedar	at NFSR	8-Oct-08	0			0/S				L/S	Live *Corbicula* only
NFSR	at Cedar Creek	8-Oct-08	7.9		0/2	0/100's	0/2	0/1	0/1	L/S	Live *Corbicula* only
Passage	Elizabeth Furnace	30-Jul-08	6.7			0/1				L/S	Live *Corbicula* only
Passage	at NFSR	24-Sep-08	0							0/S	No live mussels
NFSR	at Passage Creek	24-Sep-08	5.0			3/100's	0/2-3	0/1		L/S	1 live native species
Molly Booth	at NFSR	8-Oct-08	0							0/S	No live mussels
NFSR	boat landing off Rt. 626	8-Oct-08	4.5		0/2	5/100's	0/1	0/1	0/2	L/S	1 live native species
North	Rt. 766	26-Aug-08	NC								No mussels
Briery Branch	Rt. 748	12-Aug-09	NC								No mussels
Dry River	at North River	12-Aug-09	0							0/S	No live mussels
North	at Dry River	12-Aug-09	21.1							0/S	No live mussels
North	Rt. 993	10-Sep-09	13.9							L/S	Live *Corbicula* only
North	Rt. 668 (NW of Grottoes)	11-Aug-09	4.4	0/1		0/20+				L/S	Live *Corbicula* only

Table 3 (continued).

River	Location	Date	River Mile	*Alasmidonta undulata*	*Alasmidonta varicosa*	*Elliptio complanata*	*Elliptio fisheriana*	*Lampsilis* sp.	*Strophitus undulatus*	*Corbicula fluminea*	Comments
Middle	Rt. 728 (W of Franks Mill)	16-Sep-09	44.0							L/S	Live *Corbicula* only
Middle	Rt. 742 (SW of Mt. Pisgah)	16-Sep-09	35.6							L/S	Live *Corbicula* only
Middle	Rt. 781 (near Bald Rock)	11-Aug-09	32.7			0/4				L/S	Live *Corbicula* only
Middle	Rt. 781 (W of Verona)	16-Sep-09	29.3			0/2				L/S	Live *Corbicula* only
Lewis Creek	Rt. 931 (off Rt. 790)	11-Aug-09	3.0							L/S	Live *Corbicula* only
Christians	Rt. 635 (SW of Brand)	16-Sep-09	16.3							L/S	Live *Corbicula* only
Christians	Rt. 637/250	11-Sep-08	14.1	0/1		0/1				L/S	Fresh dead *A. undulata*
Goose	at Christians Creek	11-Sep-08	0							L/S	Live *Corbicula* only
Christians	Rt. 795	11-Sep-08	7.2			0/3-4				L/S	Live *Corbicula* only
Christians	at Middle River	7-Aug-08	0	0/3	0/1	0/30				L/S	Live *Corbicula* only
Christians	at Middle River	26-Aug-08	0		0/1	0/S			0/1	L/S	Live *Corbicula* only
Middle	at Christians Creek	26-Aug-08	17.8		0/2	0/S				L/S	Live *Corbicula* only
Middle	Rt. 926	26-Aug-08	15.0	0/1		0/S				L/S	Live *Corbicula* only
South	Cowbane Nat. Area Preserve	4-Aug-09	39.8	68/S		6/2-3			78/S	L/S	3 live native species
South	Shenandoah Wetland Mitigation Bank site, ca. 1.5 km upstream Rt. 608	9-Sep-09	39.1	9/10-20		15/0			26/0	L/S	3 live native species
South	Rt. 631 (SE of Oak Hill)	5-Aug-09	27.6			1/5				L/S	1 live native species
South	Riverview Park, Waynesboro	5-Aug-09	25.4							L/S	Live *Corbicula* only
South	Rt. 612 (Crimora)	10-Sep-09	13.8			1/0				L/S	1 live native species
South	Rt. 778 (Harriston)	10-Sep-09	7.5							L/S	Live *Corbicula* only
South	Rt. 844 (Grand Caverns)	10-Sep-09	4.2							L/S	Live *Corbicula* only
South	at SFSR	7-Aug-08	0							L/S	Live *Corbicula* only
SFSR	Rt. 708 (Lynnwood)	7-Oct-09	94.6							L/S	Live *Corbicula* only
SFSR	Bus. Hwy. 33 (Elkton)	7-Oct-09	80.4							L/S	Live *Corbicula* only
SFSR	Rt. 650 (Grove Hill)	7-Aug-08	65.0							L/S	Live *Corbicula* only
SFSR	Bus. Hwy. 340 (Alma)	7-Oct-09	57.2			0/1				L/S	Live *Corbicula* only
SFSR	Rt. 675 (Bixler's Landing)	7-Oct-09	44.1			0/3		0/1		L/S	Live *Corbicula* only
SFSR	off Rt. 684 (Fosters Landing)	6-Oct-09	34.5			1/10-12				L/S	1 live native species
SFSR	Shenandoah River State Park	6-Oct-09	15.0			1/10				L/S	1 live native species
Total live individuals (# of sites)	87 total surveys at 84 sites	2008-2009	---	77 (2)	0	56 (12)	0	0	104 (2)	---	Total of 3 live native species at 12 sites

Livestock and human use (including driving trucks and/or all terrain vehicles in the river) were noted on several occasions. These can cause high disturbances in the sediments and directly kill mussels by trampling or crushing. Additionally, livestock may introduce coliforms directly into the water. Human use also includes lower-impact activities such as swimming, canoeing, and fishing.

Currently, there are five small dams along the NFSR. The 5 ft (1.5 m) dam near Riverton (NFSR mile 0.5) is now demolished (Cooley, 2010). Dams can prevent the free passage of fish, which serve as hosts to the larval stage (glochidia) of freshwater mussels. This hampers the distribution of mussels and may restrict their recolonization of an area (Watters, 1996). The 6.5 ft (2 m) Winchester water supply dam east of Strasburg (river mile 6.5) likely prevents free movement of fish during normal river flows, but fish may be able to move upstream during high flood events. The dam at Burnshire Bridge (NFSR mile 41.7) is higher (ca. 13 ft [4 m]), likely preventing the passage of fish. All live mussels found in the NFSR during 2008 were downstream of this dam. However, live *E. complanata* were observed about 3.5 river miles above the dam in 2004 (Johnson & Neves, 2004). Surveys by DCR-DNH at the same location in 2008 did not yield any live mussels. The remaining dams are: Chapman Dam (13 ft [4 m], river mile 48.6), Edinburg Dam (16 ft [4.9 m], river mile 58.8), and Timberville Dam (6 ft [1.8 m], river mile 84.9).

There are four dams along the SFSR (Luray Dam, river mile 46.2; Newport Dam river mile 60.6; Shenandoah Dam river mile 73.8; McGaheysville Dam river mile 89.8), all of which are 15 ft (4.5 m) or higher and likely prevent fish passage. There is a 9 ft (2.7 m) high dam along the Middle River at Damtown (approximately river mile 15.8) and farther upstream is a 22 ft (6.7 m) high dam south of Swoope, Virginia. All three live *E. complanata* observed in the SFSR during the past 15 years (one each at Rt. 613 [Beaty & Neves, 1998], Fosters Landing, and Andy Guest/Shenandoah River State Park [both DCR-DNH field surveys, 2009]) were found downstream of the Luray Dam.

Finally, both the NFSR and SFSR have experienced recent, large fish kills (VDEQ, 2008a). In 2004, an estimated 80 percent of the adult Smallmouth Bass (*Micropterus dolomieu*) and Redbreast Sunfish (*Lepomis auritus*) died due to undetermined stressors. It is unknown what impact, direct or otherwise, this may have on the mussel fauna of the Shenandoah Valley.

CONCLUSIONS

Overall, current mussel habitat quality of the NFSR and SFSR is poor, resulting from many conditions including pollution, habitat alteration, and water quality concerns. Reversing the impacts of any one of these threats would be a long-term project and require cooperation from every level of government and private sector agencies, as well as numerous private landowners. The benefits of any new management plans may not be realized for many years, but action should not be delayed because recolonization of mussels has been successful in other venues (Strayer et al., 2004).

By far, the best known extant mussel community (three species) in either the NFSR or SFSR drainage inhabits the South River along the boundary of DCR-DNH's Cowbane Prairie Natural Area Preserve, extending downstream to a wetland mitigation site held by the Shenandoah Wetland Bank. This river reach may be one of the best remaining sites for *Alasmidonta undulata* and *Strophitus undulatus* populations in Virginia (B. Watson, pers. comm.). It would be prudent to develop a monitoring protocol for these populations, as well as to seek conservation initiatives such as conservation easements and land acquisition.

In general, substrate conditions throughout the surveyed areas tended to be embedded with silt and evidence of large algal blooms was common. In conjunction with other impacts on the river habitats and water quality (e.g., dams, point and non-point source pollution, etc.), overall mussel habitat quality is poor. Except for one large mussel population in the South River, observations of live mussels were typically limited to 1-5 individuals. It is unknown if such small populations can reproduce effectively. All live mussels in the NFSR and SFSR mainstems were below high dams. It is unlikely that mussel populations will be able to spread beyond these dams, thus headwater populations may be isolated from any mainstem individuals. To improve conditions for freshwater mussels in the NFSR and SFSR drainages, both water quality improvements and habitat restoration must be made.

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Range Extension for the Dismal Swamp Southern Bog Lemming, *Synaptomys cooperi helaletes*, in Eastern Virginia

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ABSTRACT

The distribution of the Dismal Swamp Southern Bog Lemming is extended to include three counties west of the Dismal Swamp in southeastern Virginia, long considered its only location in the state. Evidence of lemmings was detected at 10 of 27 survey sites, and confirmed by trapping at three of five sites, all dominated by herbaceous vegetation.

Key words: range extension, southern bog lemming, *Synaptomys cooperi.*

INTRODUCTION

Synaptomys cooperi helaletes, the Dismal Swamp Southern Bog Lemming, was discovered in the Great Dismal Swamp of southeastern Virginia in 1895 and named by C. H. Merriam (1896) as a new species of rodent. In a revision of the genus, the distinct population from the Swamp was reduced to subspecies status (Howell, 1927) and later revisions, including Wetzel (1955), have affirmed that decision. This taxon is now considered to be one of seven subspecies and among the four subspecies that occur as isolated populations (Wilson & Ruff, 1996). No specimens of *S. c. helaletes* were collected for the next 85 years despite efforts by several investigators, including Handley (1979a, b), who speculated on the possible extinction of the Dismal Swamp population. In the early years of Virginia's protected species program, the Southern Bog Lemming was classified as "status undetermined" because it was unclear whether populations existed (Handley, 1979b).

Then, in late winter 1980, Rose (1981) collected 13 specimens of the Southern Bog Lemming (hereafter 'lemming') with pitfall traps from three locations in the northwestern section of the Great Dismal Swamp National Wildlife Refuge, confirming that the population was extant. Later pitfall trapping (Everton, 1985; Padgett, 1991) revealed its presence in several locations in the Refuge and also well beyond its boundaries (see review in Rose, 2006). Information gathered in the 1980s allowed this taxon to be removed from consideration for possible state listing in 1989 (Handley, 1991). Webster and his colleagues (1992) found lemmings in a few locations in the Coastal Plain of North Carolina, raising the possibility that the species might range more widely in Virginia also. Rose (2005) reported its presence at eight of 14 survey locations in Isle of Wight County, which lies more than 30 km from the western boundary of the Refuge.

The Southern Bog Lemming is a small (<30 g) rodent in the subfamily Arvicolinae (formerly Microtinae) of the Family Muridae. Arvicoline rodents are characterized by chunky bodies, dense fur, and short ears and tails. Other arvicolines in eastern Virginia are the Meadow Vole (*Microtus pennsylvanicus*) and Woodland or Pine Vole (*Pitymys pinetorum*). All arvicolines are herbivorous, eating mostly the stems and leaves of grasses, plus some forbs and lesser amounts of other plant material. *Synaptomys* differs from other local arvicolines by having grooved upper incisors and it differs from the more common Meadow Vole by having a much shorter tail; the lemming's tail is about as long as the hind foot whereas the Meadow Vole's tail is twice as long as the hind foot. Southern Bog Lemmings have squarish noses, brownish grizzled dorsal fur, and gray belly fur. Two morphological features, grooved incisors and short tail, help distinguish Southern Bog Lemmings from other short-

tailed rodents. Woodland Voles have equally short tails but lack grooved incisors.

The presence of lemmings can be detected in the field because they produce bright green feces (Burt, 1928), a unique feature among rodents in eastern North America. The causes of the green feces are unknown but may be related to the unusual spiral-shaped caecum in the digestive tract of *Synaptomys*. Besides being green in color and ca. 2 mm long, lemming droppings are sausage-like, being rounded on both ends whereas the feces of the Meadow Vole are brownish-black and tapered on one end. Other rodents in grassy habitat have larger or smaller droppings.

When herbivorous rodents eat grasses or other monocots, often their principal food, they leave small piles of cuttings, each usually about 2-3 cm long and with diagonal cuts at the ends. Meadow Voles make and maintain runways, the thoroughfares on which they travel as they conduct their daily activities. Woodland Voles confine most of their foraging activities to the shallow (3-4 cm) burrows they construct (Smolen, 1981). It is unclear whether lemmings make runways or burrows, but at least in eastern Virginia their presence is most often related to wet herbaceous habitats, often characterized by the presence of sphagnum (*Sphagnum* spp.) or other mosses and to obligate wetland plants such as soft rushes (*Juncus* spp.), sedges (*Carex* spp.), wool grass (*Scirpus cyperinus*), and giant plume grass (*Erianthus giganteus*) (Rose, pers. obs.).

The purpose of my study was to search for the presence of lemmings in three Virginia counties west of the known distribution, namely in Surry, Sussex, and Southampton counties. The western boundaries of these counties lie 130-155 km (75-85 miles) west of Norfolk and about 100-115 km west of the Refuge. If the known distribution extends well beyond the Refuge, *Synaptomys cooperi helaletes* populations are secure.

MATERIALS AND METHODS

In previous field studies in eastern Virginia, pitfall traps often were used to confirm the presence of lemmings at locations where the habitat was suitable (Rose, 2006). However, sites where lemmings are found often are too wet for the use of pitfall traps because the hygroscopic pressure of water pushes the traps out of the ground when the water table is near the surface, as often happens in eastern Virginia during winter. The alternative method I used was to visit potential habitats in the three counties and search for the green feces indicating the presence of lemmings. At five sites where feces were detected, I used live traps baited with mixed seeds in January and February, 2011, in an attempt to confirm the presence of lemmings. Southern Bog Lemmings are difficult to capture using live traps (e.g., Rose & Stankavich, 2008), but they are most trappable in winter.

The habitats most commonly associated with the presence of lemmings are dominated by grasses and other herbaceous vegetation. I made my searches at sites near where roadways intersect with powerline rights-of-way (ROWs), habitats that often are dominated by such plants. Using county maps, I identified 13 locations in Surry County, 31 locations in Sussex County, and 22 locations in Southampton County where powerlines intersect public roads. A few more locations now exist because of the new Thrasher-Suffolk line that Dominion Virginia Power is currently constructing from Hopewell to Suffolk, Virginia. Most of the powerline ROWs were those of Dominion Virginia Power radiating from their Surry generating station, located on the James River in eastern Surry County. Most ROWs had two adjacent towers and were 60-70 m wide, providing linear habitat often bordered by farmland or forest.

At each site dominated by grassy vegetation, I spent 1-3 hours looking for the runways and cuttings characteristic of arvicoline rodents, and for the green feces associated with the presence of lemmings. At many places where a road intersected with a powerline, the ROW was under cultivation, had unsuitable shrubby or forested vegetation, or was posted against trespassing. I made searches only at sites where grassy vegetation dominated and the land was not posted.

RESULTS

I spent 14 days driving 2,361 miles to examine 27 potential sites for the presence of lemmings (Table 1). Seven sites were in Surry County (723 km^2), 11 in Sussex County (1276 km^2), and nine in Southampton County (1553 km^2). These values are roughly proportional to the number of road crossings of powerline ROWs, and similar to the miles of ROW in each county.

I found evidence of lemmings (green feces) at 10 of the 27 survey sites, including two locations in Surry County and four locations each in Sussex and Southampton counties (Table 1; Fig. 1). I set live traps at five of the most promising sites (i.e., those with numerous cuttings and green feces) and captured one or two lemmings at three of these sites, thus confirming that the green feces were accurate in predicting the presence of lemmings. (Voucher specimens are in the Old Dominion University collection.) At the other two sites, I caught only Meadow Voles or Hispid Cotton Rats (*Sigmodon hispidus*) during the time I trapped. I caught lemmings at two locations in extreme south-

Table 1. GPS coordinates associated with the 27 locations where searches were made for Dismal Swamp Southern Bog Lemmings (SBL) and a brief summary of survey results. "no" in the last column means that evidence of SBL was not detected at that site.

Surry County, Virginia, with elevations from 68 to 114 feet (21 to 35 m)					
Site 6	N37º	05.995'	W76º	42.099'	green feces, no SBL in traps
Site 7	N37º	08.573'	W76º	41.830'	no; vole cuttings and a nest
Site 1	N37º	05.084'	W76º	43.529'	no; Cotton Rat cuttings
Site 19	N37º	05.024'	W76º	45.506'	green feces, no trapping
Site 20	N37º	03.160'	W76º	46.872'	no; Meadow Voles only
Site 21	N37º	01.883'	W76º	52.801'	no; area probably too small and adjacent to forested swamp
Site 2	N37º	07.138'	W76º	51.890'	no; Meadow Voles only
Site 3	N37º	10.693'	W76º	56.444'	sphagnum, but no feces
Site 4	N37º	12.217'	W76º	59.312'	no; Cotton Rats only
Sussex County, with elevations from 72 to 177 feet (22 to 54 m)					
Site 8	N37º	02.489'	W77º	04.143'	no; area probably too small
Site 5	N37º	04.380'	W77º	09.414'	green feces, only Meadow Voles in traps
Site 11	N37º	02.040'	W77º	17.120'	no cuttings or feces
Site 12	N37º	02.685'	W77º	17.019'	no; area probably too dry and recently mowed for hay
Site 13	N37º	01.991'	W77º	09.215'	green feces, no trapping
Site 14	N37º	00.828'	W77º	03.934'	no; area disturbed
Site 15	N36º	59.492	W77º	01.821'	caught 1 SBL
Site 24	N36º	54.596'	W77º	29.444'	no cuttings or feces
Site 25	N36º	53.876'	W77º	29.793'	green feces, no trapping
Site 26	N36º	51.814'	W77º	30.835'	no; Cotton Rats only (?)
Site 27	N36º	53.821'	W77º	32.574'	no cuttings in small area
Southampton County, with elevations from 11 to 93 feet (3.5 to 28 m)					
Site 22	N36º	54.051'	W76º	54.174'	no cuttings in cattails
Site 23	N36º	53.932'	W76º	54.726'	no; habitat disturbed by recent construction
Site 18	N36º	34.884'	W77º	14.279'	caught 1 SBL+ 1 Meadow Vole
Site 17	N36º	38.397'	W77º	04.871'	1 green feces and cuttings, no trapping
Site 16	N36º	38.772'	W77º	02.998'	caught 2 SBL
Site 9	N36º	39.395'	W76º	59.214'	no cuttings or feces
Site 10	N36º	39.520'	W76º	58.326'	green feces, no trapping

western Southampton County (sites 16 and 18 between Boykins and Branchville) and at one location (site 15) in western Sussex County, about two miles (4 km) from the Prince George County line and within 20 miles (32 km) of Petersburg, Virginia. All locations were near the western boundaries of these counties, suggesting that lemmings might be present even farther to the west.

DISCUSSION

All 27 survey sites were dominated by herbaceous vegetation, mostly grasses, and saturated soils usually were present on the site or nearby. The presence of lemmings sometimes was associated with standing water on the site, often with sphagnum moss, panic grasses (*Panicum* spp.), and wool and giant plume grasses present. In the wettest sites, soft rushes (*Juncus effusus* and *J. tenuis*) also were present, and at site 16, where the piles of cuttings and green feces were especially numerous, soft rushes were the most prominent type of plant being cut and eaten. My searches in other grassy vegetation on slightly drier locations at site 16 detected few or no cuttings or droppings, indicating that, in mid-winter at least, lemmings were relying heavily on green soft rushes for food. At the 10 sites where I found bright green feces, piles of green cuttings were present, suggesting that this was the food being consumed. Lemmings were not cutting the standing dead vegetation that often was much more abundant at this (winter) season.

At the other two sites (#15 and 18) where I caught lemmings, there was little sphagnum moss, no wool grass or soft rushes, and little standing water. The grasses at these sites were dominated by little bluestem (*Schizachyrium scoparius*) and panic grasses, and a few tree seedlings were present also, indicating somewhat drier conditions.

Each of the counties that I surveyed has numerous swamps, often with slow-moving blackwater streams flowing through them (each county map has many

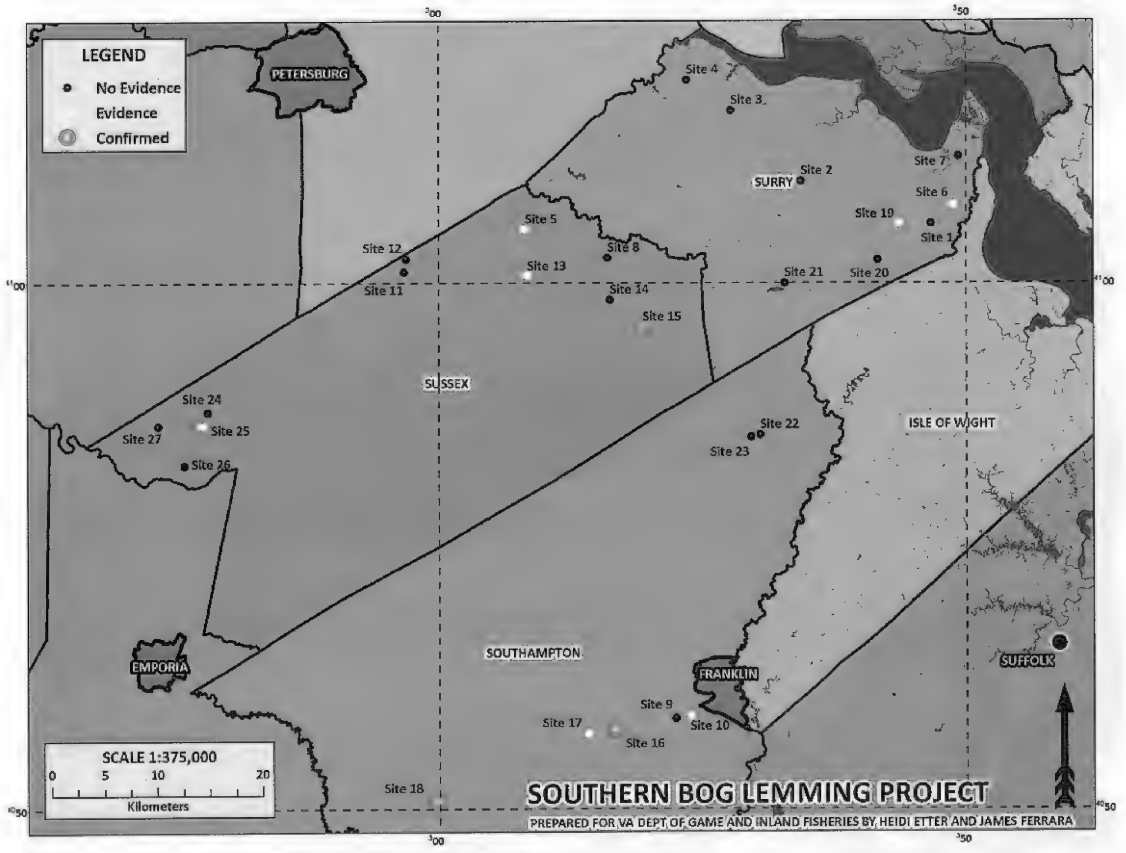

Fig. 1. Map of Surry, Sussex, and Southampton counties in southeastern Virginia showing the 27 sampling locations (powerlines at road crossings) and results of surveys for Dismal Swamp Southern Bog Lemmings.

named swamps [Surry (n=13), Sussex (n=17), and Southampton (n=9)] and countless miles of associated streams). Such swamps are present even in western Sussex County where the countryside is rolling and mean sea level elevations approached 200 feet (61 m) in some places. These conditions can produce marshes dominated by panic, wool, giant plume, and other grasses tolerant of persistently saturated soils. Sphagnum and other mosses often were present too. In these damp or wet conditions, lemmings and/or meadow voles often are present as the dominant herbivorous rodents.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this field study, Dismal Swamp Southern Bog Lemmings (*Synaptomys cooperi helaletes*) are known to occur at multiple locations in each county. Besides the locations that I documented, many more places, including powerlines distant from road crossings, probably support populations of lemmings. In addition, each county has many streamside and larger marshes associated with meandering slow-moving streams that may harbor bog lemmings.

With the addition of these three counties, the total area of known distribution of lemmings in eastern Virginia is increased to 6,996 km^2 (3,701 mi^2), which includes the cities of Virginia Beach, Chesapeake, and Suffolk, and Isle of Wight County, as reported previously (Rose, 2006), and now the counties of Surry, Sussex, and Southampton. I suspect that the next counties to the west (Prince George, Dinwiddie, and Greensville) also harbor populations of lemmings in appropriate habitat, as described in this report. It is now clear that the Dismal Swamp subspecies of the Southern Bog Lemming is not restricted in distribution to the Great Dismal Swamp, as was once believed, but has a much broader range to the west, at least south of the James River, extending to within about 30 km of Petersburg.

In light of this new information on the much greater area of distribution, I believe *S. c. helaletes* has a sufficiently broad range in Virginia such that its

populations can be considered secure. Part of the justification for this belief is that the habitat used by Southern Bog Lemmings is low-lying, often boggy land adjacent to meandering streams that is not likely to be developed beyond its present state, now mostly farmland. Furthermore, logging operations in these rural counties do not pose a threat either, because after clearing, these tracts often provide suitable habitat for lemmings for several years, and, of course, the powerline ROWs will continue to serve as habitat in many places, potentially providing corridors for lemmings to establish new populations. Thus, the habitats in which lemmings now are found are likely to continue to be present in comparable quality and number for the foreseeable future. The major threats remain in the cities of Virginia Beach, Chesapeake, and Suffolk, where development continues apace in upland sites, sometimes degrading or shrinking nearby wetlands and other low-lying habitat that might harbor lemmings.

ACKNOWLEDGMENTS

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The Occurrence of *Ramphogordius sanguineus* (Nemertea, Heteronemertea) in the Intertidal Zone of the Atlantic Coast of Virginia and New Observations on its Feeding Behavior

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ABSTRACT

The fissiparous heteronemertean *Ramphogordius sanguineus* is common among oysters and mussels on the Rudee Inlet jetty, City of Virginia Beach, Virginia. This is the first report of this species in the intertidal zone of the Atlantic coast of Virginia, but it is likely widespread along the coast. The external morphology, distribution, and life history of *R. sanguineus*, a known predator of polychaete annelids, are reviewed. A description of its feeding behavior is presented, including the novel observation that the proboscis is used to effectively immobilize or slow the locomotion of its polychaete prey (*Alitta succinea*), presumably through toxin delivery.

Key words: external morphology, heteronemertean, intertidal, macrophagous predation.

INTRODUCTION

Nemertean worms are common predators of the marine fauna, feeding on a variety of other invertebrates, including annelids, mollusks, and crustaceans (McDermott & Roe, 1985). Feeding-rates for nemerteans that prey on amphipod crustaceans and those that feed on polychaete annelids suggest that these animals have the potential to impact marine community structure (e.g., McDermott, 1984, 1993; McDermott & Roe, 1985; Ambrose, 1991; Thiel & Kruse, 2001; Caplins & Turbeville, 2011). However, the ecology of nemerteans is understudied relative to many other animal taxa, in part because species identification is often problematic. Twenty-three nemertean species were recorded in intertidal and subtidal waters of Virginia by McCaul (1963) and twenty-four were reported by Wass (1972). Recently, a new record for the state was documented by Turbeville & Caplins (2010). Herein we report the occurrence of the fissiparous heteronemertean *Ramphogordius sanguineus* (Rathke, 1799), in the intertidal zone of the Rudee Inlet jetty, City of Virginia Beach, Virginia. In addition, we present an overview of the external anatomy, distribution, and life history of this nemertean and provide new laboratory observations on its feeding behavior.

MATERIALS AND METHODS

Nemerteans were collected from the Rudee Inlet jetty, (36°49′49″ N, 75°58′06″ W) on several occasions during 2009, 2010, and 2011 by removing mussels and oysters (harboring worms) with table knives from the granite rocks, placing them in seawater-filled bags and transporting the bags to the laboratory. Bag contents were then placed in glass culture- or Pyrex baking dishes, and the worms were allowed to crawl away from the mussels and oysters, after which they were transferred to culture dishes containing clean seawater. If worms were observed in the field, they were immediately isolated from the substrate and placed in plastic bags containing seawater. Species identification was based on the description in Coe (1943) and confirmed using divergence and tree-based analyses of mitochondrial DNA cytochrome oxidase I and NADH dehydrogenase 6 gene sequences (unpublished).

For feeding analyses, individuals of the polychaete annelid *Alitta* (formerly *Nereis*) *succinea*, collected as

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above, were placed in a Pyrex dish containing one or more nemerteans, with a cleaned oyster (*Crassostrea virginica*) shell provided as a platform to mimic natural conditions. A volume of water sufficient to cover the shell was added. In some instances, the polychaetes were positioned near the nemerteans using an insect pin or pipette. Observations were made using a Nikon ZMC stereomicroscope. Feeding videos were recorded for subsequent evaluation using a Panasonic DMC-FX37 digital camera mounted on the dissecting scope. Three complete and three incomplete feeding sequences were observed and recorded. Sequences were considered complete if the following events were observed: nemertean proboscis eversion leading to partial or complete prey immobilization followed by prey consumption. Incomplete sequences were analyzed for incidences of nemertean proboscis eversion and prey response. The time from eversion to retraction of the proboscis was recorded and classified according to whether significant contact (e.g., proboscis wrapping around the prey), some contact (e.g., proboscis briefly touching the prey), or no contact was made. Widths of both nemerteans and annelid prey were measured from still images captured from the recorded videos using the program PhotofunStudio (Panasonic), and were made using Image J (Abràmoff et al., 2004). Each width measurement represents the average of three measurements taken for each animal from three different still images. Measurements were calibrated from a known distance on the *C. virginica* shell surface.

RESULTS AND DISCUSSION

Habitat, Appearance, and Distribution

Ramphogordius sanguineus, previously known as *Lineus socialis* (see Riser 1994, 1998 for taxonomic revision), occurs commonly on the Rudee Inlet jetty situated among oysters and mussels (*Mytilus edulis*). The worms are often situated in sediment that has accumulated around these sessile molluscs. Other associated fauna include the amphipods *Corophium* cf. *insidiosum*, *Hyale plumulosa*, *Jassa falcata*, the annelid *Allita succinea*, and the nemerteans *Lineus bicolor*, *Prosorhochmus americanus*, *Tubulanus pellucidus*, and *Zygonemertes virescens.*

Individuals vary in color from grayish green to light brown to brownish black or dull red with the posterior regions often appearing lighter in color (Fig. 1). Rudee Inlet jetty specimens are typically brown in color, although some exhibited a dull reddish anterior region. Riser (1994) suggested that diet possibly plays a role in this color variation. This species is characterized in part by a reddish brain, which is usually apparent in living specimens through the dorsal body wall with incident light (Riser, 1994), deep cephalic grooves on each side of the head, and a row of 3-7 reddish-brown ocelli, situated along each margin of the head (Fig. 2). In a sample of twenty worms, only three individuals exhibited an equal number of ocelli on both margins, an observation congruent with those reported by Riser (1994). Additionally, there are faintly pigmented circumferential constrictions at intervals along the body posterior to the head (Fig. 1). Representative worms collected at Rudee Inlet ranged in length from 30-70 mm and from 0.3-0.6 mm in width, but worms of up to 200 mm long and 1-2 mm wide have been reported in other populations (Coe, 1943; Riser, 1994).

Ramphogordius sanguineus has a global distribution, occurring in the subtidal and intertidal zones of primarily temperate waters. Coe (1943) mentions that along the East Coast of North America, this species occurs from the Bay of Fundy to Florida (without further discussion). This species was not encountered in the surveys of nemerteans of Virginia (Ferguson & Jones, 1949; McCaul, 1963), but is reported in the comprehensive species checklist of Wass (1972). However, because it was reported from subtidal sands (an atypical habitat) of the York River and no description is included, this record is questionable. Given that *R. sanguineus* is abundant on hard substrates in the intertidal zone north and south of Virginia, its discovery on the Rudee Inlet jetty was expected, and it was likely missed in past surveys because of its patchy distribution (pers. obs.) and sampling strategies utilized. Our observations thus verify the presence of this species in Virginia, and suggest that it is likely abundant in other fouling communities along the coast.

Besides its common association with mussels and oysters on rocky shores (Riser, 1993, 1994) and artificial hard-substrate (e.g., jetties, groins, pilings; Fox & Ruppert, 1985; pers. obs.) communities, this species also occurs in algae, beneath stones on fine sediment, or in fine sediment (Gibson, 1995, 2001) and, as pointed out by Riser (1994), Verrill (1873) lists *R. sanguineus* as a nemertean that occurs on submerged wood, buoys, and boat bottoms. This species tends to be gregarious and may be found in large numbers at a given location. It can occur syntopically with *Lineus ruber* and *Lineus viridis* in the northern reaches of its range in North America (Coe, 1943; J. Norenburg, pers. comm.), and because of overlapping color variation, it sometimes may be confused with the latter species. *Ramphogordius sanguineus* can be distinguished from *L. ruber* and *L. viridis* by its habit of coiling irregularly

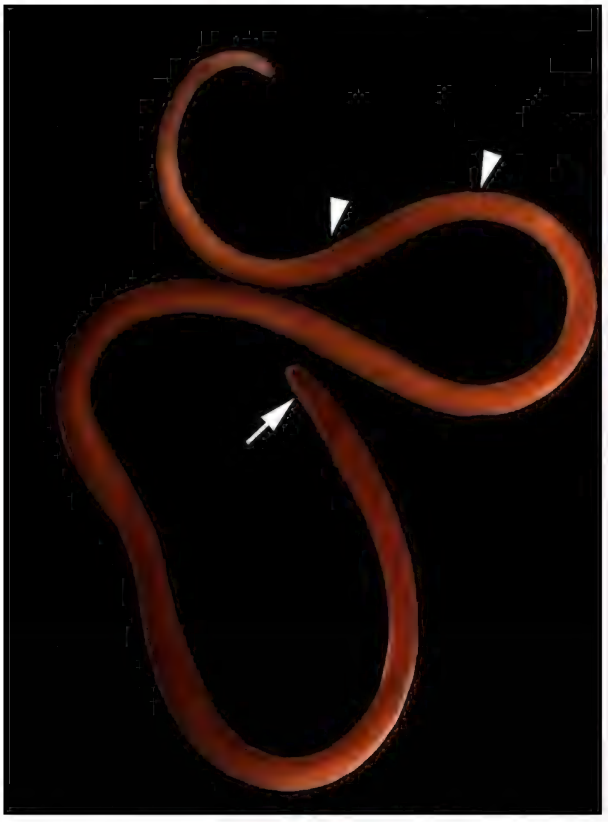

Fig. 1. Dorsal view of *Ramphogordius sanguineus*. The left cephalic groove (arrow) and some of the circumferential constrictions (arrowheads) are apparent.

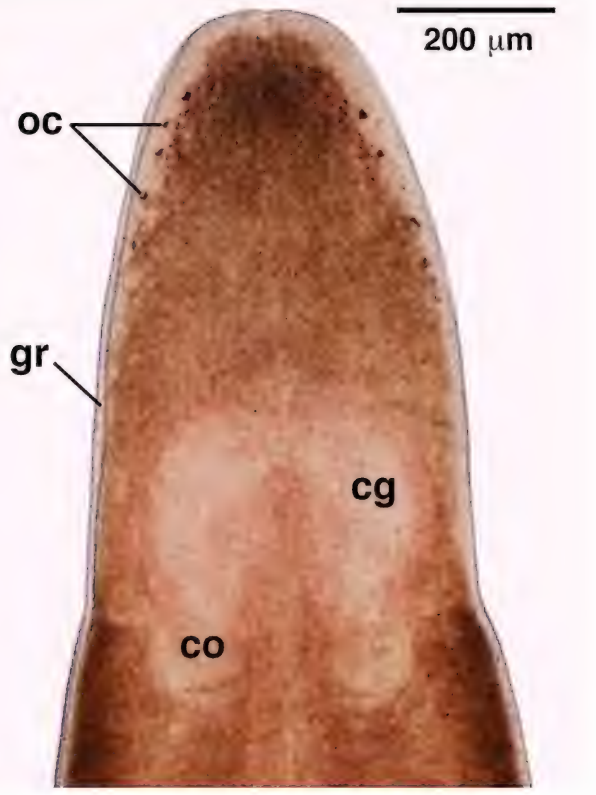

Fig. 2. Light micrograph of the anterior end of *Ramphogordius sanguineus* revealing the ocelli (oc), cerebral ganglia (cg), cerebral organs (co), and the left cephalic groove (gr).

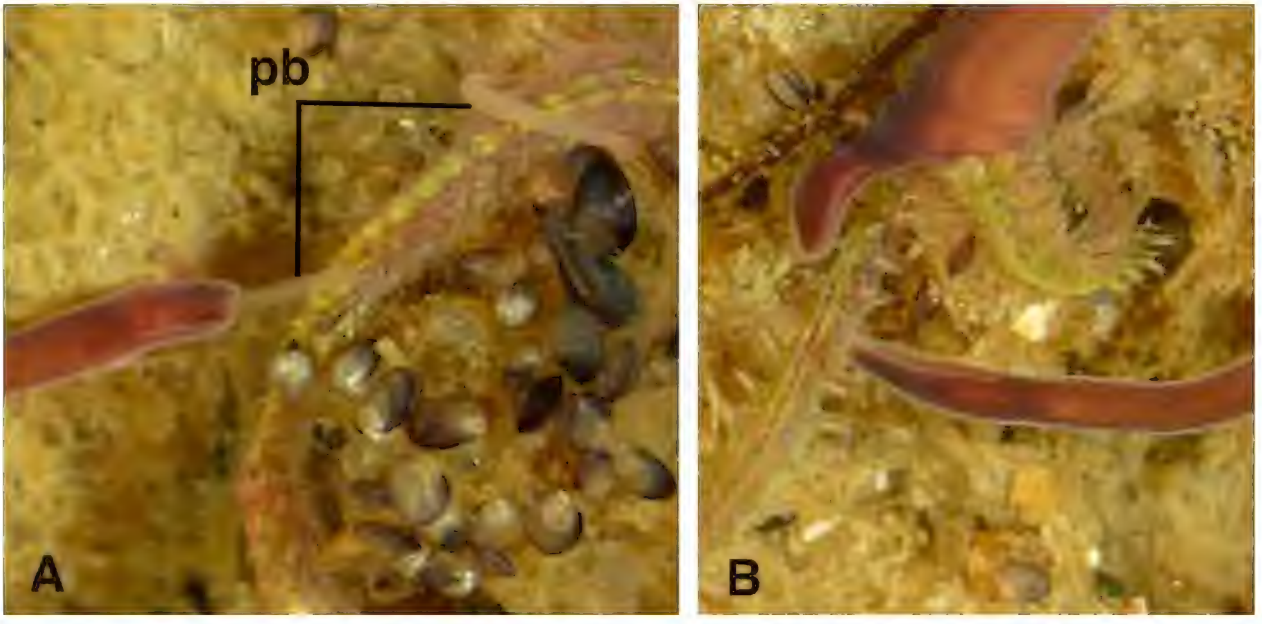

Fig. 3. Snapshots from videos of *Ramphogordius sanguineus* feeding on *Alitta succinea*. A) Image showing the everted proboscis (pb) coiled loosely around *A. succinea.* Note juvenile mussels. B) *R. sanguineus* engulfing *A. succinea* such that it forms a J-shape while another nemertean approaches.

or into a spiral when disturbed. This coiling behavior is considered diagnostic (Coe, 1943; Gibson, 2001; J. Norenburg, pers. comm.).

Ramphogordius sanguineus reproduces asexually (clonally) by fragmentation, and the previously mentioned circumferential constrictions in many cases correspond to the fission zones, although fission can occur outside these regions (Coe, 1930). Each fragment, which may encyst in mucus, develops into a complete worm by anterior and posterior regeneration (Coe, 1930). Fissiparity also distinguishes *R. sanguineus* from *L. ruber* and *L. viridis*, which are incapable of asexual reproduction and exhibit anterior regeneration only anterior to the brain (Coe, 1943).

Widespread distribution of *R. sanguineus* may be attributable to rafting on debris or transport on boat bottoms (Riser, 1993, 1994), a common mechanism of dispersal of fouling organisms (see Highsmith, 1985; Thiel & Gutow, 2005a, b). It is also possible that encysted worms, which can remain in this state for weeks or months (Coe, 1943), could be dislodged from the substrate and dispersed by water currents. Accounts of sexual reproduction in this species are fragmentary, and whether a free-swimming larval stage exists is unknown (see Coe, 1943; Riser, 1994).

Feeding Observations

Jennings & Gibson (1969) described the basic feeding mechanism of *R. sanguineus*, and many of our observations are consistent with theirs, but we provide additional details and highlight some notable differences. This species is a macrophagous predator of polychaete annelids, although when starved, it will consume oligochaetes and sometimes other nemertean species (Jennings & Gibson, 1969). In our observations, predation began with the nemertean moving toward the polychaete prey (*Allita succinea*), presumably following chemical cues (see Jennings & Gibson 1969; Roe, 1970), and then everting its proboscis, which would often coil loosely around the annelid when contact was made (Fig. 3A). Proboscis eversion was elicited either by the nemertean touching the annelid with its head and pulling back slightly before everting its proboscis, or when the annelid was within striking distance, 0.5-0.6 mm (n = 2 observations). The striking distance appeared to be greater in other instances, but for these we were unable to obtain measurements. Also, in these cases, the proboscis typically did not make contact with the annelid. The annelid's response to a proboscis strike was somewhat variable: in one instance, the annelid struggled wildly by twisting and coiling before it was effectively immobilized (lying on its dorsal surface, slowly twitching and everting its pharynx slightly) following brief contact (5 s) with the proboscis. It remained immobilized in this manner for approximately 3 min before the nemertean returned to consume the annelid whole (http://www.vimeo.com/13829966), which took approximately 80 s. In another case, the annelid appeared distressed, twisting and coiling following contact (7 s) with the nemertean proboscis, but did not show the same degree of immobilization as mentioned above, and instead appeared slightly stunned or disoriented. The annelid recovered in 10 seconds but was attacked again and consumed after 1 min.

Additionally, in several cases we observed the nemertean everting its proboscis after it had attached its mouth to the annelid. In an observation involving two nemerteans, one everted its proboscis five times and the other three times as they attempted to swallow the still struggling annelid, which they succeeded in immobilizing and consuming. These preliminary observations suggest that the proboscis of *R. sanguineus* delivers toxins to immobilize or at least partially slow its prey, in contrast to the claim of Jennings & Gibson (1969) that it is used only to wrap tightly around and pull the annelid towards the mouth of the nemertean. We observed only two cases in which the proboscis may have played a minor role in gripping the prey, making brief contact (4 s and 3 s, respectively) before the annelid was released. The proboscis is equipped with secretory cells that produce rod-shaped structures, termed pseudocnidae (see Turbeville, 2006) that could serve to grip and possibly puncture prey (Jennings & Gibson, 1969), thus allowing toxin entry, but we were unable to document their role in the capture or immobilization of *A. succinea*.

In six separate feeding observations involving a total of 14 nemerteans and six annelids, 32 instances of nemertean proboscis eversion occurred. Half (16) of these eversions made significant, although somewhat loose, contact with the prey item (coiling or wrapping around it), and the proboscis was fully retracted after an average of 5.3 s (range = 2-16 s) of contact with the annelid prey. The remaining proboscis eversions either made no contact (n = 10, mean = 2.2 s, range = 1.5-3 s) or made some contact (n = 6, mean = 3.3 s, range = 3-4 s). These data support our observations that proboscis contact with prey is typically relatively brief and is likely the primary means of immobilizing prey through toxin delivery. However, it is unclear from our limited number of observations whether a correlation exists between the degree of annelid immobilization and the duration of contact with the proboscis.

Concurrently, or shortly following proboscis

eversion, the mouth of the nemertean (subterminal to the head/proboscis pore) dilates as it crawls towards its annelid prey. Once the mouth makes contact with the prey, peristaltic waves of the body-wall musculature, along with mucous secretions from gland cells located in the buccal cavity and foregut (see Jennings & Gibson, 1969), aid in the engulfment of the immobilized or partially immobilized annelid (Fig. 3B). Occasionally, the head appeared to be pressed against the prey and used to hold and guide the annelid into the nemertean's mouth, but during other predation events was raised above the annelid as the mouth dilated and when the annelid was engulfed (Fig. 3B; see Jennings & Gibson, 1969; Wang et al., 2008). *Ramphogordius sanguineus* does not appear to have a preference for the orientation of the prey item preceding consumption; we observed annelids being consumed linearly, either head-first, or tail-first, as well as folded over into a V or J shape, depending on where along the annelid body the nemertean began to engulf it (Fig. 3B).

The consumption time of two predation events, both involving five nemerteans attacking one annelid, was 4 min 50 s and 3 min 25 s (width measurements were unattainable for these events). For predation events involving one nemertean, the consumption times are as follows: 1 min 20 s for a nemertean of 0.632 mm (SD = 0.02) in width and an annelid 0.676 mm (SD = 0.03) in width, and 50 s for a nemertean 0.52 mm (SD = 0.05) wide that consumed about 1/3 of the posterior end of an annelid 0.56 mm (SD = 0.08) wide, torn off against the sharp edge of an oyster shell. These consumption rates are within the range documented for the palaeonemertean *Procephalothrix simulus* consuming the polychaete *Saccocirrus gabrillae*, that had been partially or completely immobilized by the nemertean's proboscidal toxins (Wang et al., 2008), and are broadly consistent with Roe's (1970) observations concerning macrophagous predation by the hoplonemertean *Paranemertes peregrina* on polychaetes when the prey item was less than the diameter of the dilated mouth of the nemertean.

We made three observations involving multiple nemerteans feeding on one annelid. These events were similar to those involving one nemertean, but with some notable behavioral differences. Namely, each nemertean that approached the site of predation exhibited proboscis eversion, regardless of the annelid's state of immobilization. Additionally, the nemerteans were each able to consume some portion of the annelid by pinching off pieces of the annelid, a process likely aided by the release of digestive enzymes and the muscular contractions of each nemertean's mouth and foregut (http://www.vimeo.com/24638715; see Jennings & Gibson, 1969).

Throughout our observations of predation events, the annelid prey (*Allita succinea*) exhibited putative anti-predatory responses when in close proximity to the nemerteans, including agitation, rapid crawling, swimming, and pharynx eversion. In one case the annelid secreted mucus in a trail behind it perhaps to facilitate escape or slow the advance of the nemertean, and in other cases a swimming response was elicited and were it not for the confines of the dish, and our return of the annelid back to the feeding arena, the annelid likely would have escaped predation. Controlled experiments will be necessary to verify if the observed behaviors represent escape responses.

Our qualitative observations suggest that *A. succinea* is the most abundant errant polychaete in the jetty fouling community, but whether it is the favored prey of *R. sanguineus* will remain unknown until feeding preference studies are conducted.

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The Carabidae (Insecta: Coleoptera) of Eastern Neck National Wildlife Refuge, Maryland

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ABSTRACT

We documented 80 species of Carabidae during inventory work conducted at Eastern Neck National Wildlife Refuge, Rock Hall, Maryland from April to September 2003. *Chlaenius erythropus* Germar and *Clivina striatopunctata* Dejean are reported from Maryland for the first time. This increases the total number of Carabidae recorded from Maryland from 368 to 370.

Key words: Carabidae, inventory, Eastern Neck National Wildlife Refuge, new state records.

INTRODUCTION

The Carabidae (ground beetles) are commonly found under stones or bark, or running over the ground. Ground inhabitants are found on the shores of streams and ponds, sunlit marshes, swamp forests, wet or dry forests, wet meadows, dry grasslands, and exposed sandy areas. Some species live in trees or shrubs and may be taken by beating or sweeping foliage (Larochelle & Lariviére, 2003). Most carabids are generalist predators or scavengers, eating dead and dying arthropods, or are specialist predators feeding on mollusks, millipedes, or various insect groups. Some species are day-active, relying on eyesight primarily to capture prey while others are nocturnal, locating prey by chemical means. Other carabids are plant feeders, especially on seeds. A few species are ant nest associates, feeding on ants and debris from the nest (Larochelle & Lariviére, 2003). Many carabids are attracted to lights and can be collected this way as well as by head-lamping. Unbaited pitfall traps are another effective method of collecting these beetles. Malaise traps, flight-intercept traps, and Berlese funnel samples capture numerous species. The 2,635 North American species are fairly well-studied (Ball & Bousquet, 2000), but a few genera are in need of revision. Mid-Atlantic carabids can be identified using Ciegler (2000) and Bousquet (2010).

The carabid fauna of Maryland includes 368 confirmed species, while 87 other species may occur in the state (Bousquet & Larochelle, 1993; Bailey et al., 1994; Clark et al., 2006; Steiner et al., 2007). By comparison, 504 carabids have been documented in Virginia (Davidson, 1995; Anderson et al., 1995; Hoffman & Roble, 2000; Hoffman et al. 2006; Evans 2009b). Very little has been published on Maryland carabids. Glaser (1976, 1986, 1992, 1995) reported on various Cicindelini and Staines (2005[2006]) reported on *Cicindela hirticollis hirticollis* Say colonizing a restored beach. Staines (1994) surveyed the genus *Calosoma* using black lights and he also (Staines, 1985) discussed the biology and distribution of the genus *Omophron* in the state. Bailey et al. (1994) reported on carabids collected in pitfall traps in western Maryland and Dively (2005) used this sampling method to study the impact of transgenic corn on carabid diversity and abundance. Glaser (1996) discussed the ten Cychrini species found in Maryland and Clark et al. (2006) compared the carabid faunas in two tillage systems. More recently, Evans (2009a) listed 46 species of carabids found at Maryland sites during the Potomac Gorge Bioblitz. The only published inventory of the carabid fauna of a Maryland location accounts for 214 species from Plummers Island, Montgomery County

collected over an 80-year period, but only 117 of these species were taken from 1970 to 1984 (Erwin, 1981; Stork, 1984).

Eastern Neck National Wildlife Refuge, located south of Rock Hall in Kent County, Maryland (39.0149°N, 76.1341°W), is a 2,285 acre (914 ha) Chesapeake Bay island at the mouth of the Chester River (Fig. 1). Habitats include 860 acres (344 ha) of brackish tidal marsh, 550 acres (220 ha) of cropland (primarily corn and soybeans with some clover and winter wheat), 700 acres (280 ha) of forest (composed of loblolly pine, hardwoods, and mature oak-sweetgum forest), 30 acres (12 ha) of grassland, and 40 acres (16 ha) of open water impoundments. The elevation varies from 13 to 23 feet (2.9 to 6.9 m) above mean sea level.

METHODS

We used three methods to collect ground beetles on the refuge. Unbaited barrier pitfall traps containing soapy water as a killing agent were placed in various locations on the island and their contents were collected daily. Visual encounter surveys were conducted in specific habitats throughout the island. Finally, we used black lights for several nights each month, resulting in the collection of numerous species.

Inventories were conducted from 22 April to 20 September 2003. Voucher specimens have been deposited in the collections of Eastern Neck National Wildlife Refuge and the National Museum of Natural History, Smithsonian Institution.

Fig. 1. Map of Eastern Neck National Wildlife Refuge.

ANNOTATED LIST OF SPECIES

Tribe Bembidiini

Bembidion affine Say, 1823 is commonly found in a variety of habitats characterized by open or slightly shady ground covered with moderate to dense vegetation. Adults are active for the entire season and are the overwintering stage (Lindroth, 1963; Erwin, 1981). Adults were collected in June along Bayview Butterfly Trail, Boxes Point, Cedar Point, and Ingleside Recreation Area at black light.

Bembidion honestum Say, 1823 is usually found along the banks of rivers and streams and prefers open, moist, gravelly soil. Adults are mostly nocturnal and found under rocks and stones during the day (Lindroth, 1963; Erwin, 1981). One specimen was collected along the shoreline at Cedar Point on 30 May 2003.

Bembidion inaequale Say, 1823 is usually found along the banks of rivers, streams, ponds, and pools, preferring wet soil with little vegetation. Adults are diurnal and feed on dead and dying arthropods (Lindroth, 1963; Erwin, 1981). Specimens were collected at black light in June and July at Ingleside Recreation Area and in the Maintenance Yard.

Bembidion rapidium (LeConte, 1848) is usually found along lake shores, the banks of rivers, streams, ponds, and pools as well as in orchards and cultivated fields. The species prefers open wet or moist ground with some vegetation. Adults are nocturnal and shelter in cracks in the soil or under dead leaves or stones during the day. They feed on immature Lepidoptera and the larvae and pupae of Diptera (Lindroth, 1963; Kirk, 1975; Erwin, 1981). Specimens were collected at black light at Ingleside Recreation Area on 27 June 2003.

Elaphropus levipes (Casey, 1918) is usually found on open ground along river banks (Erwin, 1981). Specimens were collected at black light from April to August at Bogles Wharf, Boxes Point, Ingleside Recreation Area, Maintenance Area, and along Wildlife Trail.

Tribe Brachinini

Brachinus cyanipennis Say, 1823 is found along the banks of rivers and brooks, lake shores, floodplain forests, and borders of marshes. Adults are nocturnal and found on open or shaded ground. Larvae are ectoparasites of Gyrinidae pupae (Coleoptera) (Lindroth, 1969; Erwin, 1970; Larochelle, 1974). One specimen was collected at black light on 26 June 2003 at Boxes Point.

Brachinus tenuicollis LeConte, 1844 is found along the margins of rivers, ponds, pools, reservoirs, and marshes. Adults are nocturnal and are found on open or half-shaded ground. The larvae are ectoparasites of Hydrophilidae larvae (Coleoptera) (Lindroth 1969; Erwin 1970; Larochelle, 1974). Specimens were collected in pitfall traps in July and August at Bogles Wharf, Boxes Point, Field 25, Ingleside Recreation Area, and Wicke's Historic Site.

Tribe Carabini

Calosoma sayi Dejean, 1826 is found in a diversity of habitats. Adults are mostly active at sunset and sunrise, are attracted to lights, and feed on larvae of Heteroptera, Lepidoptera, and Coleoptera (Burgess & Collins, 1917; Kirk, 1969, 1970; Young, 1984; Ciegler, 2000). One specimen was collected at black light in GTR 2 and 3 on 26 June 2003.

Calosoma scrutator (Fabricius, 1775) is found in a wide variety of habitats but prefers shaded ground. Adults are nocturnal and will feed on anything they can overpower (Blatchley, 1910; Burgess & Collins, 1917; Lindroth, 1961; Erwin, 1981). Specimens were collected from May to August in pitfall traps, black lights, and during visual encounter surveys along Bayview Butterfly Trail, Bogles Wharf, Boxes Point, Cedar Point, Ingleside Road, and along Wildlife Trail.

Calosoma wilcoxi LeConte, 1848 is found on shaded ground in a wide variety of habitats. Adults feed on Lepidoptera larvae and grasshoppers (Orthoptera: Acrididae) (Burgess & Collins, 1917; Lindroth, 1961). One specimen was collected in a pitfall trap on 17 May 2003 along Wildlife Trail.

Carabus goryi Dejean, 1831 is found on shaded ground in a wide variety of habitats. Adults are nocturnal and gregarious; they feed on soft-bodied insect larvae (Blatchley, 1910; Liebherr & Mahar, 1969; Erwin, 1981). Specimens were commonly collected in pitfall traps in April and May at Bogles Wharf, Boxes Point, Field 25, and along Wildlife Trail.

Tribe Chlaeniini

Chlaenius aestivus Say, 1823 is found in shaded moist habitats well away from open water. Adults are

nocturnal and gregarious. Eggs are laid in mud or clay cells placed on dead twigs, leaves, plant stems, and trunks of trees and shrubs (King, 1919; Lindroth, 1969; Erwin, 1981). Specimens were commonly collected in pitfall traps from April to June at Bogles Wharf, Boxes Point, Field 25, Ingleside Recreation Area, Visitor Center, Wicke's Historic Site, and along Wildlife Trail.

Chlaenius cordicollis Kirby, 1837 is found on open ground along the shores of large lakes and rivers, close to the water. Adults and larvae are active at night and are gregarious. They feed on dead or injured insects (Lindroth, 1969; Erwin, 1981). One specimen was collected in a pitfall trap on 29 July 2003 along the road to Ingleside Recreation Area.

Chlaenius erythropus Germar, 1824 is found on shaded ground of mature floodplain forests, edges of swamps, lakes, and ponds. Adults are nocturnal and gregarious. They feed on Lepidoptera larvae and earthworms (Blatchley, 1910; Lindroth, 1969). One specimen was collected in a pitfall trap at Ingleside Recreation Area on 24 July 2003. Bousquet & Larochelle (1993) reported that this species is widespread in eastern North America but they had no records from Maryland. This is the first documented record for the state. **NEW STATE RECORD**

Chlaenius sericeus sericeus (Forster, 1771) is found in a wide variety of habitats but especially around water. Adults are mostly nocturnal and gregarious. They feed on a variety of insects and earthworms (Blatchley, 1910; King, 1919; Lindroth 1969; Erwin, 1981). Specimens were collected in June at black light along Wildlife Trail.

Chlaenius tricolor tricolor Dejean, 1826 is found in a wide variety of habitats. Adults are nocturnal, and gregarious in the winter. They feed on Lepidoptera larvae and slugs (Blatchley, 1910; Lindroth, 1969). Specimens were collected from May to August at black light and in pitfall traps along Bayview Butterfly Trail, Bogles Wharf, Boxes Point, GTR 2 & 3, Ingleside Recreation Area, Visitor Center, Wicke's Historic Site, and along Wildlife Trail.

Tribe Cicindelini

Cicindela hirticollis hirticollis Say, 1817 is found on the seashore, the shores of rivers and lakes and may be abundant on wet beach sand (Graves et al., 1988). Adults were abundant from May to August at the restored beach near Bayview Butterfly Trail, Cedar Point, and Ingleside Recreation Area.

Cicindela marginata Fabricius, 1775 is found in a variety of habitats but seems to prefer beaches and intertidal habitats with mud and debris (Knisley & Schultz, 1997). One specimen was collected on 25 July 2003 at black light at Cedar Point and a second was collected the same day during visual encounter surveys near Bayview Butterfly Trail.

Cicindela punctulata punctulata Olivier, 1790 occurs in a wide variety of habitats but is usually found in open areas or areas with sparse vegetation (Knisley & Schultz, 1997). Adults and larvae feed on a variety of small arthropods and adults are often taken at lights (Erwin, 1981; Ciegler, 2000). One specimen was collected at black light at Ingleside Recreation Area on 12 August 2003.

Cicindela repanda repanda Dejean, 1825 is commonly found in a wide variety of habitats, usually associated with water (Knisley & Schultz, 1997). Adults and larvae feed on a variety of small arthropods and adults are reported to feed on earthworms (Erwin, 1981). The species was common along the beach at Ingleside Recreation Area.

Cicindela sexguttata Fabricius, 1775 is found in forested areas and open areas adjacent to woodlands (Knisley & Schultz, 1997). Adults feed on small spiders, Lepidoptera larvae, gnats, beetles, and ants (Erwin, 1981). Specimens were collected from May to July in pitfall traps and during visual encounter surveys at Bogles Wharf, GTR 2 & 3, and along Wildlife Trail.

Tribe Clivinini

Clivina bipustulata (Fabricius, 1801) is found in open ground in a wide variety of habitats. Adults are nocturnal and spend the day in burrows dug in the soil. They are associated with Staphylinidae (Coleoptera) and Formicidae (Hymenoptera) (Lindroth, 1961; Kirk, 1969; Erwin, 1981). Specimens were collected in May and June at black light along Bayview Butterfly Trail, Boxes Point, and along Wildlife Trail.

Clivina dentipes Dejean, 1825 is found on open ground in floodplain forests, along the banks of rivers, streams, and other bodies of water. Adults are nocturnal and shelter in burrows dug in the soil and under rocks, logs, pieces of wood, and leaf litter (Kirk, 1969; Erwin, 1981). Specimens were collected in May and June at black light along Bayview Butterfly Trail, Boxes Point, and along Wildlife Trail.

Clivina ferrea LeConte, 1857 is found on moist open ground in a wide variety of habitats. Adults are nocturnal and shelter during the day in burrows dug in the soil or under stones and debris (Lindroth, 1961; Erwin, 1981). Specimens were collected from May to July at black light and during visual encounter surveys along Bayview Butterfly Trail, Cedar Point, Maintenance Area, and the Staff Residence.

Clivina striatopunctata Dejean, 1831 is found in swamps, along the shores of lakes and streams, and in cultivated fields. Adults are nocturnal and shelter during the day in burrows dug in the soil or under debris (Leng, 1915). Specimens were collected in May and June in pitfall traps and at black light along Bayview Butterfly Trail and Boxes Point. Bousquet & Larochelle (1993) reported this species from Alabama, Delaware, Florida, Georgia, Louisiana, Mississippi, South Carolina, and Texas. This is the first report from Maryland. **NEW STATE RECORD**

Dyschiriodes sphaericollis (Say, 1823) is found on open ground close to water. Adults are nocturnal and gregarious. They have been associated with Staphylinidae (Coleoptera) (Lindroth, 1961; Kirk 1975; Erwin, 1981). One specimen was collected at black light on 26 June 2003 in GTR 2 & 3.

Tribe Cychrini

Sphaeroderus stenostomus stenostomus (Weber, 1801) is found mostly on shaded ground in deciduous forests and along the borders of marshes. Adults are mostly nocturnal and feed on slugs and snails (Ulke, 1902; Erwin, 1981). Specimens were collected from April to July in pitfall traps at Boxes Point, Field 25, along Ingleside Road, and along Wildlife Trail.

Tribe Galeritini

Galerita bicolor (Drury, 1773) is found on shaded ground mostly in deciduous forests. Adults are nocturnal and feed on a variety of insects and on carrion (Blatchley, 1910; King, 1919; Erwin, 1981; Ciegler, 2000). Specimens were collected from May to July in pitfall traps and at black light at Field 25, GTR 2 & 3, Hail Point, Ingleside Recreation Area, Visitor Center, Wicke's Historic Site, and along Wildlife Trail.

Tribe Harpalini

Amphasia interstitialis (Say, 1823) is found on shaded ground in deciduous floodplain forests. Adults are nocturnal and feed on insects and decaying vegetable matter (Blatchley, 1910; Lindroth, 1968; Erwin, 1981). One specimen was collected at black light on 14 June 2003 along Bayview Butterfly Trail.

Anisodactylus agricola (Say, 1823) is found on shady ground of floodplain forests. Adults are nocturnal and are found during the day under stones and leaf litter (Erwin, 1981; Noonan, 1996). Specimens were commonly collected from April to June in pitfall traps along Bayview Butterfly Trail, Bogles Wharf, Boxes Point, Field 25, and Visitor Center.

Bradycellus rupestris (Say, 1823) is found on open ground in a wide variety of habitats. Adults feed on small worms (Lindroth, 1968; Kirk, 1969; Erwin, 1981). Specimens were collected from May to July at black light along Bayview Butterfly Trail, Boxes Point, Cedar Point, Maintenance Area, and along Wildlife Trail.

Cratacanthus dubius (Palisot de Beauvois, 1811) is found on open ground in a wide variety of habitats. Adults are mostly nocturnal and feed on small insects (Blatchley, 1910; Lindroth, 1968; Erwin, 1981; Ball & Bousquet, 2000). One specimen was collected in a pitfall trap on 20 June 2003 at Ingleside Recreation Area.

Harpalus caliginosus (Fabricius, 1775) is found on open ground in a wide variety of habitats. Adults are both diurnal and nocturnal and feed on seeds, plant pollen, and a variety of insects (Blatchley, 1910; Lindroth, 1968; Erwin, 1981; Noonan, 1991). Specimens were collected in June and July at black light and in pitfall traps along Bayview Butterfly Trail, GTR 2 & 3, Ingleside Recreation Area, and Staff Residence.

Harpalus erythropus Dejean, 1829 is found on open ground in a wide variety of habitats. Adults are nocturnal and feed on beetle larvae (Blatchley, 1910; Lindroth, 1968; Erwin, 1981). Specimens were collected in May and June at black light along Bayview Butterfly Trail, Boxes Point, GTR 2 & 3, Ingleside Recreation Area, and along Wildlife Trail.

Harpalus herbivagus Say, 1823 is found on open ground in a wide variety of habitats. Adults are mostly nocturnal and active in the spring and fall; they feed on grass seeds, fungi, and a variety of insects (Lindroth, 1968; Erwin, 1981; Noonan, 1991). Specimens were collected in May and June at black light and during visual encounter surveys along Bayview Butterfly Trail, GTR 2 & 3, and Ingleside Recreation Area.

Harpalus longicollis LeConte, 1848 is found on open ground in a wide variety of habitats. Adults are nocturnal and feed on Scarabaeidae larvae (Coleoptera) (Lindroth, 1968; Erwin, 1981). One specimen was collected on 26 June 2003 at black light along Bayview Butterfly Trail.

Harpalus pensylvanicus (DeGeer, 1774) is found on open ground in a wide variety of habitats. Adults are mostly nocturnal and feed on plant seeds, plant tissue, pollen, and a wide variety of insects (Blatchley, 1910; Lindroth, 1968; Erwin, 1981). Specimens were collected from April to September in pitfall traps, at black light, and during visual encounter surveys along Bayview Butterfly Trail, Boxes Point, Cedar Point, along Duck Inn Trail, Hail Point, along Ingleside Road, Visitor Center, and Staff Residence.

Harpalus sp. One specimen that we could not identify to species was collected on 14 June 2003 at black light along Bayview Butterfly Trail.

Notiobia nitidipennis (LeConte, 1848) is found in light or open deciduous forests. Adults are nocturnal and feed on various insects (Blatchley, 1910; Leng, 1915; Lindroth, 1968; Noonan, 1973; Erwin, 1981). Numerous specimens were collected on 29 May 2003 at black light at Boxes Point.

Stenolophus comma (Fabricius, 1775) is found on open ground in a wide variety of habitats. Adults are mostly nocturnal and feed on a variety of insects (Johnson, 1949; Lindroth, 1968; Hsin et al. 1979; Erwin, 1981). Specimens were collected from May to July at black light at Boxes Point, Cedar Point, GTR 2 & 3, along Bayview Butterfly Trail, Ingleside Recreation Area, Staff Residence, and along Wildlife Trail.

Stenolophus ochropezus (Say, 1823) is found in a variety of habitats associated with water. Adults are nocturnal and feed on seeds (Blatchley, 1910; Leng, 1915; Lindroth, 1968; Erwin, 1981). Specimens were collected from May to August at black light along Bayview Butterfly Trail, Boxes Point, Cedar Point, along Duck Inn Trail, GTR 2 & 3, Ingleside Recreation Area, along Ingleside Road, Maintenance Area, Staff Residence, and along Wildlife Trail.

Stenolophus rotundicollis (Haldeman, 1843) is found on open ground in various field-like habitats. Adults are nocturnal and hide under debris during the day (Lindroth, 1968; Kirk, 1970). Specimens were collected in May and June at black light and during visual encounter surveys along Bayview Butterfly Trail, Boxes Point, Cedar Point, and GTR 2 & 3.

Trichotichnus fulgens (Csiki, 1932) is found on open and shaded ground in a wide variety of habitats. Adults are mostly diurnal and fly readily (Erwin, 1981; Noonan 1991). Specimens were collected in May and June in pitfall traps and at black light at the Visitor Center and along Wildlife Trail.

Tribe Lebiini

Calleida viridipennis (Say, 1823) is found in open forests and swamps. Adults are mostly diurnal and feed on Lepidoptera larvae (Leng, 1915; Erwin, 1981; Braun et al. 1990). One specimen was collected at black light on 29 May 2003 at Boxes Point.

Cymindis limbatus Dejean, 1831 adults are largely arboreal and taken on tree trunks and in the canopy at night and under bark and in cracks in trees during the day. Adults feed on Lepidoptera larvae and carrion (Blatchley, 1910; Liebherr & Mahar 1979; Erwin, 1981; Ciegler, 2000). Specimens were collected in May and June at black light at Boxes Point and GTR 2 & 3.

Lebia analis Dejean, 1825 is found on open ground in a variety of habitats. Adults are mostly diurnal and feed on a wide variety of insects (Blatchley, 1910; Whitcomb & Bell, 1960; Lindroth, 1971; Erwin, 1981). Specimens were collected from June to August at black light at GTR 2 & 3 and along Wildlife Trail.

Lebia fuscata Dejean, 1825 is found on shaded or open ground in light or open forests and adjacent meadows and clearings. Adults are mostly diurnal and feed on the immature stages of Chrysomelidae (Coleoptera) (Cushman & Isely, 1916). One specimen was collected at black light on 26 June 2003 at Boxes Point.

Lebia grandis Hentz, 1830 is found on open ground in a variety of habitats. Adults are mostly diurnal and feed on a variety of insects but especially immature Chrysomelidae (Coleoptera) (Blatchley, 1910; Hemenway & Whitcomb, 1967). Specimens were collected from May to August at black light along Bayview Butterfly Trail, Boxes Point, Ingleside Recreation Area, and along Wildlife Trail.

Lebia solea Hentz, 1830 is found on slightly shaded or open ground in a variety of habitats. Adults are mostly diurnal and are ectoparasites of Chrysomelidae pupae (Coleoptera) (Blatchley, 1910; Larochelle, 1974;

Erwin, 1981). Specimens were collected in June at black light along Bayview Butterfly Trail.

Lebia viridis Say, 1823 is found on open or slightly shaded ground in a wide variety of habitats. Adults are mostly diurnal and feed on the immature stages of Chrysomelidae (Coleoptera) (Blatchley, 1910; Hemenway & Whitcomb, 1967; Lindroth, 1969; Erwin, 1981). Specimens were collected from June to September during visual encounter surveys and at black light along Bayview Butterfly Trail, Cedar Point, GTR 2 & 3, along Ingleside Road, and Staff Residence.

Plochionus timidus Haldeman, 1843 is found on shaded ground in deciduous forests and swamps. Adults are both nocturnal and diurnal and feed on Lepidoptera larvae (Blatchley, 1910; Emden, 1942; Erwin, 1981). One specimen was collected in a pitfall trap on 14 July 2003 at Bogles Wharf.

Tribe Licinini

Badister notatus Haldeman, 1843 is found on open ground in disturbed habitats and forest clearings. Adults are nocturnal (Lindroth, 1969; Larochelle, 1974; Kirk 1975; Erwin, 1981). Specimens were collected in June at black light along Bayview Butterfly Trail, Boxes Point, and GTR 2 & 3.

Dicaelus elongatus Bonelli, 1813 is found on shaded ground mostly in deciduous forests. Adults are nocturnal and feed on Lepidoptera larvae (Lindroth, 1969; Kirk, 1970, 1975; Erwin, 1981). One specimen was collected in a pitfall trap on 9 May 2003 along Wildlife Trail.

Dicaelus politus Dejean, 1826 is found on shaded ground in deciduous forests. Adults are nocturnal and feed on Lepidoptera larvae (Lindroth, 1969; Erwin, 1981). Specimens were collected in June and July in pitfall traps at Bogles Wharf and along Wildlife Trail.

Dicaelus teter Bonelli, 1813 is found on shaded ground in forests. Adults are nocturnal and feed on snails and Lepidoptera larvae (Ball, 1959; Barr, 1969; Erwin, 1981). Specimens were collected from April to July in pitfall traps and during visual encounter surveys at Bogles Wharf, Boxes Point, Field 1, Field 25, Hail Point, Ingleside Recreation Area, Visitor Center, Wicke's Historic Site, and along Wildlife Trail.

Tribe Loxandrini

Loxandrus velocipes Casey, 1918 is found on wet soil covered by debris along the margins of streams and marshes and on deciduous forest floodplains. Adults are nocturnal and spend the day hidden in leaf litter (Lindroth, 1966; Allen, 1972; Erwin, 1981). Specimens were collected in June in pitfall traps along Bayview Butterfly Trail and Wicke's Historic Site.

Tribe Notiophilini

Notiophilus aeneus (Herbst, 1806) is found on shaded ground in various forest habitats and is often found in leaf litter. Adults are mostly diurnal and feed on Lepidoptera larvae (Lindroth, 1961; Erwin, 1981; Reeves et al. 1983; Ciegler, 2000). Specimens were collected in April in pitfall traps at Bogles Wharf and Field 25.

Notiophilus novemstriatus LeConte, 1848 is found on open ground in various forest habitats. Adults are diurnal and feed on Diptera (Frost, 1941; Thompson & Allen, 1974; Erwin, 1981). One specimen was collected on 9 May 2003 in a pitfall trap at Bogles Wharf.

Tribe Odacanthini

Colliuris pensylvanica (Linné, 1767) is found on open ground in a wide variety of habitats. Adults are active both day and night and feed on a variety of insects (Blatchley, 1910; Kirk, 1969; Erwin, 1981). Specimens were collected in June and July at black light along Bayview Butterfly Trail and Staff Residence.

Tribe Oodini

Oodes amaroides Dejean, 1831 is found on shaded ground in swamps, and the borders of marshes, lakes, and ponds. Adults are active day and night and when alarmed will dive into the water to escape (Leng, 1915; Kirk, 1969; Lindroth, 1969; Erwin, 1981). Specimens were collected from June to August at black light at Boxes Point, Cedar Point, Field 25, GTR 2 & 3, along Ingleside Road, and along Wildlife Trail.

Oodes americanus Dejean, 1826 is found on shaded soft, muddy soil covered with dead leaves and some vegetation; adults are nocturnal (Bousquet, 1996). One specimen was collected on 9 May 2003 in a pitfall trap at Bogles Wharf.

Tribe Platynini

Agonum extensicolle (Say, 1823) is found on open or shaded ground close to water. Adults are mostly

nocturnal and feed on a variety of insects (Lindroth, 1966; Erwin, 1981). Specimens were collected from April to August in pitfall traps and at black light along Bayview Butterfly Trail, Bogles Wharf, Ingleside Recreation Area, along Ingleside Road, and along Wildlife Trail.

Agonum octopunctatum (Fabricius, 1798) is found on open, moist ground usually close to water. Adults are mostly nocturnal and feed on Lepidoptera larvae (Blatchley, 1910; Lindroth, 1966; Kirk 1969; Erwin, 1981). Specimens were collected from June to August at black light along Bayview Butterfly Trail, Ingleside Recreation Area, and along Ingleside Road.

Agonum palustre Goulet, 1969 is found on ground shaded by trees in deciduous woodland swamps, floodplain forests, and marshes. Adults are nocturnal (Goulet, 1969). Specimens were collected at black light on 7 June 2003 along Wildlife Trail.

Agonum rigidulum (Casey, 1920) is found on moist soil near river banks in floodplain forests. Adults are nocturnal (Erwin, 1981). Specimens were collected in June at black light in GTR 2 & 3 and along Wildlife Trail.

Agonum tenue (LeConte, 1854) is found on open ground along the margins of bodies of water. Adults are nocturnal and feed on various insects (Lindroth, 1966; Kirk, 1969; Erwin, 1981). Specimens were collected in June in pitfall traps and at black light along Bayview Butterfly Trail and Wicke's Historic Site.

Calathus opaculus LeConte, 1854 is found on open or shady ground in a wide variety of habitats. Adults are gregarious and mostly nocturnal (Lindroth, 1966; Anderson et al., 1995). Specimens were collected in June and July in pitfall traps at Cedar Point, Ingleside Recreation Area, and Wicke's Historic Site.

Olisthopus parmatus (Say, 1823) is found on shaded ground in deciduous forests. Adults are nocturnal and feed on various insects and earthworms (Lindroth, 1966; Larochelle, 1974; Erwin, 1981). One specimen was collected on 26 June 2003 at black light along Bayview Butterfly Trail.

Platynus cincticollis (Say, 1823) is found on shaded ground in low deciduous forests near lakes, ponds, running water, or in swamp or floodplain forest. Adults are mostly nocturnal and feed on plant seeds (Blatchley, 1910; Kirk, 1970; Erwin, 1981). Specimens were collected in June at black light along Bayview Butterfly Trail.

Platynus decentis (Say, 1823) is found on shaded ground in deciduous forests and usually close to water. Adults are mostly nocturnal and feed on Lepidoptera larvae (Gilbert, 1957; Lindroth, 1966; Reeves et al. 1983). Specimens were collected from April to June in pitfall traps and at black light at Bogles Wharf, Boxes Point, Field 25, GTR 2 & 3, and along Wildlife Trail.

Tribe Pterostichini

Gastrellarius honestus (Say, 1823) is found on shaded ground with thick leaf litter in deciduous forests found mostly under bark or in wood except when foraging. Adults are nocturnal and feed on Lepidoptera larvae (Blatchley, 1910; Lindroth, 1966; Barr, 1969; Erwin, 1981). One specimen was collected on 14 June 2003 at black light along Bayview Butterfly Trail.

Myas coracinus (Say, 1823) is found on shaded ground in deciduous forests. Adults are nocturnal and shelter under dead leaves, logs, and stones (Lindroth, 1966; Erwin, 1981). Specimens were collected in May in pitfall traps at Boxes Point and Field 25.

Poecilus lucublandus lucublandus (Say, 1823) is found on open or slightly shaded ground in a wide variety of habitats. Adults are mostly nocturnal and may be active at low temperatures under the snow. They feed on a wide variety of insects (Blatchley, 1910; Lindroth, 1966; Barlow, 1970; Erwin, 1981). Specimens were collected from April to July in pitfall traps along Bayview Butterfly Trail, Bogles Wharf, Boxes Point, Field 25, Hail Point, Ingleside Recreation Area, along Ingleside Road, Visitor Center, Maintenance Area, and along Wildlife Trail.

Pterostichus coracinus (Newman, 1838) is found on shaded or open ground, mostly in forests but also in a wide variety of habitats. Adults are nocturnal and feed on a wide variety of insects (Blatchley, 1910; Lindroth, 1966; Barr, 1969; Erwin, 1981; Reeves et al. 1983). Specimens were collected from April to June in pitfall traps at Bogles Wharf, Boxes Point, Field 25, and along Wildlife Trail.

Pterostichus hamiltoni G. H. Horn, 1880 is found on shaded ground in open deciduous forests. Adults are gregarious and nocturnal (Larochelle & Larivière, 2003). One specimen was collected on 3 July 2003 in a pitfall trap at Boxes Point.

Pterostichus trinarius (Casey, 1918) is found on shaded ground in deciduous forests and along rivers, streams, ravines, and slopes. Adults are nocturnal and feed on insects (Kirk, 1975; Erwin, 1981). Specimens were collected in May at black light along Wildlife Trail.

Tribe Scaritini

Scarites subterraneus Fabricius, 1775 is found on open ground in a wide variety of habitats, where it is subfossorial, in burrows during the day and often deeper in the litter at night. Adults are nocturnal and feed on a wide variety of insects (Blatchley, 1910; Leng, 1915; Lindroth, 1961; Erwin, 1981). Specimens were collected in May and June in pitfall traps and at black light along Bayview Butterfly Trail, Ingleside Recreation Area, Visitor Center, Wicke's Historic Site, and along Wildlife Trail.

Tribe Zabrini

Amara aenea (DeGeer, 1774) is found on open ground in a wide variety of habitats. Adults are mostly diurnal and feed on a wide variety of insects and seeds (Lindroth, 1968; Erwin, 1981; Larochelle & Lariviere, 2003). Specimens were collected from April to July in pitfall traps, at black light, and during visual encounter surveys along Bayview Butterfly Trail, Bogles Wharf, Boxes Point, Cedar Point, Field 25, GTR 2 & 3, Visitor Center, Staff Residence, Wicke's Historic Site, and along Wildlife Trail.

Amara basillaris (Say, 1823) is found in lowland habitats. Adults are nocturnal and spend the day under leaves or in clumps of vegetation (Blatchley, 1910; Kirk, 1969, 1970, 1975). Specimens were collected from April to June in pitfall traps along Bayview Butterfly Trail, Bogles Wharf, Ingleside Recreation Area, Visitor Center, Wicke's Historic Site, and along Wildlife Trail.

Amara musculis (Say, 1823) is found on open ground in a wide variety of habitats. Adults are mostly diurnal and feed on seeds, pollen, and animal matter (Blatchley, 1910; Lindroth, 1968; Erwin, 1981). Specimens were collected from April to September in pitfall traps and during visual encounter surveys along Bayview Butterfly Trail, Bogles Wharf, Boxes Point, Field 25, Ingleside Recreation Area, Visitor Center, and along Wildlife Trail.

DISCUSSION

Our documentation of 80 species of Carabidae at Eastern Neck National Wildlife Refuge indicates that the refuge has a diverse fauna. Since our sampling was limited to one collecting season, this number represents only a fraction of the total fauna. Using EstimateS (Colwell, 2009), the estimated carabid fauna of Eastern Neck NWR is 116 species. Our collection of 68% of the estimated fauna in one season is an excellent start in documenting the total fauna of the island.

Our results compare well with the 117 species recently found at Plummers Island (Erwin, 1981; Stork, 1984) and the 114 species found at Quantico Marine Corps Base in northern Virginia (Anderson et al., 1995; Hoffman, 2010). However, comparing the survey efforts of the sites shows a much longer and intensive effort at Plummers Island (1970-1979) and Quantico (parts of 4 years). Furthermore, the survey methods were quite different. Sampling at Plummers Island did not involve the use of pitfall traps and very little black lighting was conducted. Instead, almost all of the sampling effort was by visual encounter surveys of specific habitats by experienced field collectors. The Quantico samples were obtained by using unbaited pitfall traps for two years and black lighting for parts of two seasons.

Also, both Plummers Island and Quantico are along the Fall Line where the Coastal Plain and Piedmont abut, which provides the potential for a wider diversity of microhabitats and may increase the number of species found. Eastern Neck is entirely in the Coastal Plain and mainly consists of seasonally flooded woodlands and meadows with a few higher points of drier pine-oak woods. This difference in habitat is reflected in the fact that only 63 (78%; Sørensen's Index of Similarity 0.639) of the species found at Eastern Neck were also found at Plummers Island and only 32 species (40%; Sørensen's Index of Similarity 0.329) were shared with Quantico (see Table 1 for a list of species).

The literature on carabid inventory and ecological assessment deals mostly with the use of pitfall traps (Luff, 1975; Adis, 1979; Baars, 1979; Durkis & Reeves, 1982; Boyd, 1985; Halsall & Wratten, 1988; van den Berghe, 1992; Spence & Niemelä, 1994) as the sole method of estimating diversity and abundance. However, numerous researchers have raised questions about the effectiveness of pitfall traps and the interpretation of the results (see Koivula, 2011 and Kotze, 2011 for reviews of the issues).

Table 1. Species of Carabidae collected at Eastern Neck National Wildlife Refuge that have been found at Plummers Island, Maryland, and Quantico Marine Corps Base, Virginia.

Tribe/ Species	Eastern Neck	Plummers Island	Quantico MCB
Bembidiini			
Bembidion affine	x	x	
Bembidion honestum	x	x	
Bembidion inaequalis	x	x	
Bembidion rapidum	x	x	
Elaphropus levipes	x	x	
Brachinini			
Brachinus cyanipennis	x	x	
Brachinus tenuicollis	x		
Carabini			
Calosoma sayi	x		
Calosoma scutator	x	x	
Calosoma wilcoxi	x		x
Carabus goryi	x		x
Chlaeniini			
Chlaenius aestivus	x	x	x
Chlaenius cordicollis	x	x	
Chlaenius erythropus	x		
Chlaenius sericeus	x	x	x
Chlaenius tricolor	x	x	x
Cicindelini			
Cicindela hirticollis	x		
Cicindela marginata	x		
Cicindela punctulata	x	x	
Cicindela repanda	x	x	
Cicindela sexguttata	x	x	x
Clivinini			
Clivina bipustulata	x	x	x
Clivina dentipes	x	x	x
Clivina ferrea	x	x	
Clivina striatopunctata	x		
Dyschiriodes sphaericollis	x	x	
Cychrini			
Sphaeroderus stenostomus	x	x	x
Galeritini			
Galerita bicolor	x	x	x
Harpalini			
Amphasia interstitialis	x	x	x
Anisodactylus agricola	x	x	x
Bradycellus rupestris	x	x	
Cratacanthus dubius	x	x	x
Harpalus caliginosus	x	x	x
Harpalus erythropus	x	x	x
Harpalus herbivagus	x	x	x
Harpalus longicollis	x	x	
Harpalus pensylvanicus	x	x	x
Harpalus sp.	x		
Notioba nitidipennis	x	x	
Stenolophus comma	x	x	
Stenolophus ochropezus	x	x	
Stenolophus rotundicollis	x	x	x
Harpalini (continued)			
Trichotichnus fulgens	x		
Lebiini			
Calleida viridipennis	x	x	x
Cymindis limbatus	x	x	
Lebia analis	x	x	
Lebia fuscata	x		
Lebia grandis	x	x	x
Lebia solea	x	x	
Lebia viridis	x	x	x
Plochionus timidus	x	x	x
Licinini			
Badister notatus	x	x	x
Dicaelus elongatus	x	x	x
Dicaelus politus	x	x	x
Dicaelus teter	x	x	
Loxandrini			
Loxandrus velocipes	x	x	
Notiophilini			
Notiophilus aeneus	x	x	x
Notiophilus novemstriatus	x	x	
Odacanthini			
Colliuris pensylvanica	x	x	
Oodini			
Oodes amaroides	x	x	
Oodes americanus	x		
Platynini			
Agonum extensicolle	x	x	
Agonum octopunctatum	x	x	
Agonum palustre	x		
Agonum rigidiulum	x	x	
Agonum tenue	x	x	
Calathus opaculus	x		
Olisthopus parmatus	x	x	x
Platynus cincticollis	x	x	
Platynus decentris	x	x	x
Pterostichini			
Gastrellarius honestus	x	x	
Myas coracinus	x	x	x
Poecilus lucublandus	x	x	x
Pterostichus coracinus	x	x	x
Pterostichus hamiltoni	x		
Pterostichus trinarius	x		x
Scaritini			
Scarites subterraneus	x	x	
Zabrini			
Amara aenea	x	x	
Amara basillaris	x		
Amara musculis	x	x	

The three inventory projects conducted in the mid-Atlantic revealed some of the weaknesses of using one collection technique to determine carabid diversity at a locality. At Quantico, black lights collected 36 species (32% of the total fauna) not found in pitfall traps (Anderson et al., 1995; Hoffman, 2010). At Eastern Neck, black lights collected 40 species (50% of the total fauna) not found in pitfall traps. Three additional species (4% of the fauna) were only collected during visual encounter surveys. Even at well-collected sites like Plummers Island, the use of black lights for only four nights yielded 11 species not previously documented on the island (Stork, 1984). This indicates that a variety of techniques are needed to obtain a good sample of the carabid fauna and that no one technique is the best for all sites.

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Shorter Contributions

Banisteria, Number 38, pages 85-86

FIRST VIRGINIA RECORDS FOR TWO BOREAL SPECIES OF LONGHORN BEETLES (COLEOPTERA: CERAMBYCIDAE). — In contrast with many other large families of insects, the cerambycid fauna of Virginia is relatively well-known, with 241 species now documented (VMNH unpublished files). This figure is of course inadequate in the sense that many of these species have been found only once (and then often decades in the past), and incomplete insofar as many species remain to be discovered in the Commonwealth, being known either from adjoining states or from sites both north and south of our boundaries. This occasion is taken to increase the present roster by two species of northern affinities, neither of them frequently collected in the southern Appalachians.

Tribe Callidiini

This predominantly Holarctic group is closely associated with coniferous and northern hardwood forests. Eleven genera were listed for North America by Linsley (1964), five of them represented in the Virginia fauna. Two additional genera are herewith added from material incidentally discovered by field work conducted during the summer of 2011.

Pronocera collaris collaris (Kirby)

In its broad sense, this beetle occurs transcontinentally from Newfoundland to Alaska, extending southward through the Cordilleran and Appalachian mountains and northward to the edge of the Arctic Ocean in Yukon Territory. A localized subspecies, *P. c. lecontei* Chemsak, occurs in the Sierras of northern California. In eastern North America, the species has been found southward only to Michigan, New York, and New Hampshire, with a notably disjunct record for western North Carolina (cf. Fig. 5 in Linsley, 1964). The existing nearly 700 mile (1125 km) hiatus can now be partly bridged by the discovery of this rare species in extreme western Virginia.

Highland County: Unnamed headwater tributary of Laurel Fork, ca. 0.5 mi/0.8 km west of Va. Rt. 642 [ca. 5.6 mi/9.0 km NW Hightown], 3600 ft. (1100 m), Malaise trap, 17 June-5 August 2011, S. M. Roble (VMNH 1♀).

The North Carolina record has never been formally documented. Dr. David Kavanaugh informs me that the California Academy of Sciences collection contains a single specimen labeled only "Black Mtns. NC". Dr. E. C. Van Dyke collected at Mount Mitchell in June and July of 1902, and is almost certainly the source of this record, although he did receive further samples of beetles from the Black Mountains collected by his friend William Beutenmuller, who conceivably might have obtained the specimen. Inquiries addressed to other museums likely to have material from western North Carolina disclosed no further material of *P. collaris*, which must be accounted very rare in the southern Appalachians.

Ropalopus sanguinicollis (Horn)

Despite its moderate size and conspicuous black and red colors, this species has appeared in the literature only a few times since its description 151 years ago (Horn, 1860) from specimens collected in "northern New York". The New York state list (Leonard, 1928) provided several localities in the mountainous part of that state and Linsley (1964) summarized the range as "Eastern Canada and northeastern United States to Ohio and West Virginia." Knull (1946) cited only two Ohio localities.

Grayson County: Grayson Highlands State Park, picnic area at Massie's Gap, 4650 ft. (1417 m), 20 June 2011, R. L. Hoffman (VMNH 1♂). The specimen was under attack by an asilid fly when noticed.

The species is not listed for North Carolina by Brimley (1938, 1942) and Wray (1950, 1967) nor represented in the collection of North Carolina State University. However, the National Museum of Natural History contains a specimen labeled "Mt. Mitchell, June 24, 1939" which constitutes a new southernmost locality for *Ropalopus sanguinicollis* as well as a new record for North Carolina.

ACKNOWLEDGEMENTS

Robert S. Anderson, Patrice Bouchard, Lee H. Herman, Jr., Robert L. Blinn, Steven Lingafelter, and David Kavanaugh searched through collections under their care for relevant records; Steven M. Roble donated the specimen of *Pronocera collaris*. Their collective aid during preparation of this note is gratefully acknowledged.

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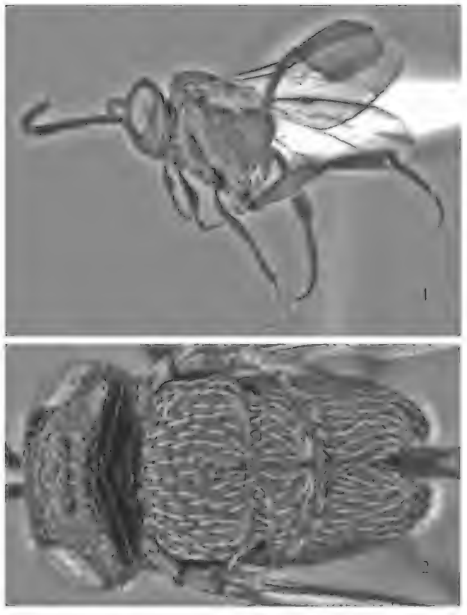
Banisteria, Number 38, pages 86-87

AN ENSIGN WASP (HYMENOPTERA: EVANIIDAE) NEW TO VIRGINIA. — Five species of Evaniidae have been recorded in Virginia, *Prosevania fuscipes* (Illiger), *Evaniella semaeoda* Bradley, *Hyptia harpyoides* Bradley, *H. thoracica* (Blanchard), and *H. reticulata* (Say) (Smith, 1998). A sixth species, *Evania appendigaster* (Linnaeus), no doubt occurs in the state. I have seen records from the District of Columbia, but as yet none from Virginia. *Prosevania fuscipes* and *E. appendigaster* are introduced species and are found only in buildings in urban situations. In extensive collections in Virginia, I have never collected either of these species in field conditions. The other species are native and occur throughout the state. All are cockroach egg predators. Little is known of the host association of native species, but they are probably *Parcoblatta* spp. or other wood roaches common in the eastern forests (Smith, 1998).

Here I record an additional species for Virginia, *Hyptia floridana* Ashmead (Figs. 1, 2). Specimens were taken in Malaise traps in Sussex and Isle of Wight counties, with the following data (number of specimens in parentheses): VA: Sussex Co., Chub Sandhill Natural Area Preserve, N36.751350° W077.489929°, 25 May-28 June 2011, A. V. Evans, D. T. Loomis, Malaise trap (5), 28 June-18 July 2011 (2), 19 July-19 August 2011 (1); VA: Isle of Wight Co., Blackwater Ecological Preserve, site 1, N36.82328°, W076.85229°, 30 June 2010, pine/oak sandhills, A. V. Evans, D. T. Loomis (1), 9 July 2010 (4), same data except site 2, N36.82261°, W076.85532°, 18 June 2010 (1), 9 July 2010 (1), 28 July 2010 (1). Townes (1949) examined specimens of *H. floridana* only from Florida, Georgia, Louisiana, Guatemala, and Panama. Subsequently, it has been recorded from St. Pauls, Robeson Co., in southeastern North Carolina (Ahlstrom, 1995; Deans, 2005). Thus, this is a new northern record for the species as well as the first state record for Virginia.

Chub Sandhill Natural Area Preserve features a series of low sand hills and adjacent riparian wetlands along the Nottoway River (VDCR, 2010; Roble & Hoffman, 2011). The Blackwater Ecological Preserve consists of dry to mesic sand ridges (Frost & Musselman, 1987). Both areas support some rare and unusual plants and animals for Virginia and northern records for southern species.

Hyptia floridana is separated from other Nearctic evaniids by Townes (1949). In the key to evaniids of the mid-Atlantic states by Smith (1998), it will go to other *Hyptia* species but can be separated by its tiny size, only about 2.0–2.3 mm long, the punctures on the



Figs. 1-2. *Hyptia floridana*. 1, Lateral view, length 2.0 mm. 2, Dorsal view of head and mesosoma.

frons tending to form transverse rows, and the short mesoscutum about 0.54 as long as wide (Fig. 2). Other species of *Hyptia* are about 5 mm or more in length, the punctures on the frons are irregular, and the mesonotum is longer, from 0.70 to as long as wide.

The host of *Hyptia floridana* is unknown. Deyrup & Atkinson (1993) speculated that it may be one of several cockroach species in southern Florida whose egg cases are appropriately small enough to serve as hosts: *Campsodes cucullatus* (Saussure and Zehntner), *Cariblatta lutea* (Saussure and Zehntner), *Cariblatta minima* Hebard, *Chorisoneura texensis* Saussure and Zehntner, and *Euthlastoblatta gemma* (Hebard). Only *Cariblatta lutea* has been recorded from southeastern Virginia (Hoffman, 1997). *Chorisoneura texensis* occurs as far north as North Carolina and Tennessee, but Atkinson et al. (1991) indicated that it could occur in southern Virginia.

Specimens are deposited in the National Museum of Natural History, Smithsonian Institution, Washington, DC, and the Virginia Museum of Natural History, Martinsville, VA.

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Banisteria, Number 38, page 88

A NEW EARLY HATCHING RECORD FOR *PLESTIODON FASCIATUS* (SAURIA, SCINCIDAE) IN VIRGINIA. — The onset of life history phenophases, such as egg laying and hatching, in ectotherms has occurred about two weeks earlier in recent times in northern latitudes apparently due to the effects of climate change (e.g., Terhivuo, 1988; Beebee, 1995; Gibbs & Breisch, 2001; Kusano & Inque, 2008). A recent observation of a reptile hatching suggests that the earlier occurrence of life history events may also be occurring in Virginia. Hatching dates of *Plestiodon fasciatus* (Common Five-lined Skink) in Virginia were reported by Mitchell (1994) to occur between 8 July and 4 August based on museum and literature records and field observations known to the early 1990s. The previous early hatching date of 8 July was derived from a laboratory incubation of a clutch of eggs I found on 16 June 1981 in Charlotte County, VA. The observation by W.H. Robertson of a naturally-incubated neonate on a garden flowerpot in Amherst, VA, reported here for 28 June 2011 extends the known early record by 10 days. This date is consistent with the earliest observation of a Common Five-lined Skink hatchling in North Carolina on 27 June (Palmer & Braswell, 1995). Hatchlings have first been observed in West Virginia on 15 July (Green & Pauley, 1987), 10 July in Maryland (McCauley, 1945), 5 August in New Jersey (R. Zappalorti, pers. comm.), and late July in Arkansas (Trauth et al., 2004). It is not possible to determine with this single observation whether timing of egg-laying and hatching in this skink are related to climate change. Numerous additional observations are needed to discern patterns. Thus, reports of the timing of life history events in Virginia should be published regularly so that a phenological database can be accumulated to evaluate the effects of climate change on the amphibians and reptiles in this region. Furthermore, all phenological records from existing data bases, unpublished theses, and other records should be sought, collated, and published to allow comparisons that may reveal changes in historical patterns.

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Banisteria, Number 38, pages 89-98

Alton McCaleb Harvill, Jr. (1916-2008): A Necrology and Tribute

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ABSTRACT

Alton M. Harvill, Jr., Professor Emeritus of Biology at Longwood University, died on February 21, 2008 at age 91. Dr. Harvill was most certainly the foremost authority on the Virginia flora, specializing in documenting the geographical distribution of plants. At Longwood University, he established the Harvill-Stevens Herbarium, a collection of approximately 75,000 specimens considered one of the finest and most significant systematic collections of vascular plants in the mid-Atlantic region. As a memorial tribute, this paper summarizes his personal and professional history and lifetime accomplishments, and provides a complete list of his scientific publications.

Key words: A. M. Harvill, Jr., Atlas of the Virginia Flora, Virginia botany, Virginia Botanical Associates.

INTRODUCTION

Dr. Alton McCaleb Harvill, Jr., Professor Emeritus of Biology at Longwood University, died on February 21, 2008 at age 91 in Cape Carteret, North Carolina, surrounded by his beloved caretakers, Sarah Kreitowitz Maddox and her daughter, Tiffany K. Bergeron. He is interred in the Westview Cemetery in Farmville, Virginia. He was preceded in death on January 29, 1988 by his devoted wife, Barbara Jean Hopkins Harvill, originally from Minneapolis, Minnesota.

Dr. Harvill was most certainly the foremost authority on the Virginia flora, specializing in documenting the geographical distribution of plants. He was the chief author of the *Atlas of the Virginia Flora, Part I, Pteridophytes through Monocotyledons* (Harvill et al., 1977), *Atlas of the Virginia Flora, Part II: Dicotyledons* (Harvill et al., 1981), *Atlas of the Virginia Flora, Second Edition* (Harvill et al., 1986), and *Atlas of the Virginia Flora, III* (Harvill et al., 1992). A long-time systematic collector of plants from across Virginia, he established the Harvill-Stevens Herbarium at Longwood College (now Longwood University, LU), a collection that is considered one of the finest and most significant assemblages of vascular plant specimens in the mid-Atlantic region. He left behind many loyal friends in local and regional botanical circles formed through years of dedicated research in botany, and particularly on the flora of Virginia.

EARLY LIFE

Alton McCaleb Harvill, Jr. was born on November 20, 1916 in Russellville, Logan County, Kentucky, to Alton M. Harvill, Sr. and Della Doss Harvill. He had one sister, Thelma Harvill.

Dr. Harvill grew up in Princeton, Kentucky and as a youth enjoyed working with plants in his father's greenhouse. He was educated in the Princeton public school system and graduated in 1934 from R. E. Butler High School. Dr. Harvill then attended Murray State Teachers College for two years. After completing some classes at the University of Idaho, he finished his undergraduate work at the University of Kentucky (UK), receiving his B.S. degree in 1939 (Fig. 1). He immediately re-enrolled at UK to pursue graduate work; then, taking a break, he worked for a year at a plant operated by U.S. Steel Company in Pittsburg, California. Dr. Harvill returned to Lexington, Kentucky and completed the M.S. requirements in the summer of 1941 under the direction of Professor B. B. McInteer.

Dr. Harvill's Master's thesis, *The Compositae of Kentucky*, documented several state records at that time including *Aster lateriflorus* L. Britton var. *angustifolius* Wiegand (from Whitley County), *Solidago bootii* Hooker (McCreary County), *Vernonia fasciculata*

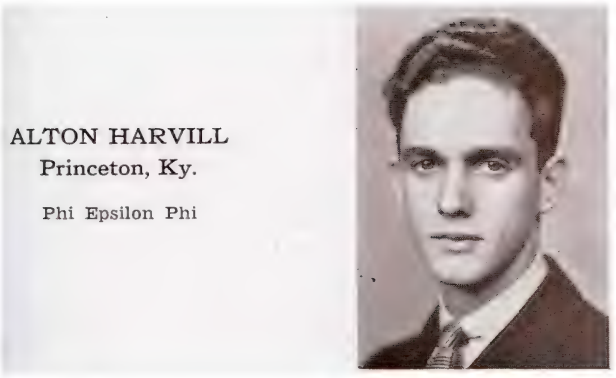

Fig. 1. Alton M. Harvill, Jr., photographed as a college junior in the 1938 *Kentuckian*, the University of Kentucky Yearbook. Provided with permission by Matthew A. Harris, UK Archives Records Program Assistant.

Michaux (Ballard County), and *Iva ciliata* Willdenow (Ballard County), the latter record based on a previously misidentified herbarium specimen. In all, Dr. Harvill processed collections representing 219 species from 57 genera and 10 tribes of this plant family (Asteraceae). Unfortunately, most, if not all, of Dr. Harvill's M.S. thesis voucher specimens were lost in the November 1948 fire that destroyed the early herbarium collections and large botanical library first established at UK by Frank T. McFarland and others[1] (Jones, 2005).

After receiving the M.S. degree, Dr. Harvill attended classes at the University of Michigan Biological Station (UMBS) at Douglas Lake, Michigan. He then received a UMBS assistantship at the University of Wyoming (UW) and briefly curated the Rocky Mountain Herbarium at UW prior to entering military service on March 12, 1942.

Dr. Harvill enlisted in the U. S. Army for the duration of WWII plus six months as a private at Fort Benjamin Harrison, Indiana, and was assigned as a service-unlimited warrant officer's assistant[2]. He also served as a medical lab technician and was posted mostly in Alaska where he began to amass a large collection of mosses. He was discharged with the rank of Technician Fifth Grade on October 9, 1945.

In March 1946, Dr. Harvill returned to the University of Michigan (UM) to complete additional coursework and begin research to support his dissertation. In June 1948, under the tutelage of Dr. William Campbell Steere, UM Botany Department Chairman (Crum, 1977), he finished his dissertation, *A Phytogeographic Study of Alaskan Mosses*. Other members of his dissertation committee were Professors Harley H. Barlett, Dow V. Baxter, Carl D. LaRue, and William R. Taylor. In his dissertation, Dr. Harvill acknowledged assistance from several bryologists, including Drs. A. L. Andrews, Seville Flowers, Winona H. Welch, and Mr. E. B. Bartram, all of whom guided Dr. Harvill through some difficult lichen genera. It is likely that Dr. Harvill was a contemporary of Howard A. Crum, another of Steere's students at UM, who became a renowned bryologist. Crum attended UM from 1947 to 1951 and after graduation, followed William Steere to Stanford University for a three-year post-doctoral appointment (Buck, 2002). Crum also taught bryology classes at UMBS, so it is possible that he and Dr. Harvill interacted there or at UM while Harvill was finishing his terminal degree and Crum was starting his graduate studies.

Prior to finishing his terminal degree requirements, Dr. Harvill published two papers on Alaskan mosses, and after receiving his doctorate, he published three more papers on mosses while teaching at the University of Alabama (UA) from 1948 to 1953. In July 1949, Dr. Harvill found what he believed to be a new species of moss in virgin hardwood forest in King Cove, Lawrence County, Alabama, naming it *Diphyscium cumberlandianum* (Harvill, 1950)[3].

After his appointment at UA ended, Dr. Harvill conducted rubber research in Liberia in 1953-54 on a 10,000 acre plantation. He returned to the U.S. in 1955; then, after a grand tour of Europe, settled into a teaching position at River Falls State College (RFSC, now University of Wisconsin-River Falls). Feeling an urge to travel, Dr. Harvill and his wife, Barbara Jean, left RFSC in the fall of 1956 for Cairo, Egypt, where he operated a "one-man biology department" at the American University at Cairo (AUC). Mrs. Harvill served as the Administrative Assistant to AUC president Raymond McLain.

At AUC, Dr. Harvill chiefly taught courses without a textbook, and was said to be extremely well organized as an instructor. In addition to other duties, he taught an undergraduate course in genetics, and upon learning the students wanted an advanced course, petitioned the

[1] http://www.ca.uky.edu/Forestry/herbarium.php.

[2] The National Archives World War II Army Enlistment Records (1938-1946) website, http://aad.archives.gov/aad/record-detail.jsp?dt=893&rid=5409141.

[3] In 2000, Z. L. K. Magombo annotated the type specimen *Harvill*, 5464, at the Gray Herbarium (barcode 00060529) to *Diphyscium mucronifolium* Mitten. Source: [http://kiki.huh.harvard.edu/databases/specimensearch.php?mode=details&id=65909]. Schofield (2007) incorporated Magombo's revision (2003) into the *Flora of North America Volume 27* treatment for *Diphyscium*.

AUC Dean to allow him to teach it. Students were described as having started off shakily at first, but in the end were very grateful for the experience and proud of their achievements. Dr. Harvill remarked on his amazement that all 200 students in his class finished the course. Dr. Harvill often talked about his stint at AUC. Though of short duration, it was one of his favorite academic experiences. He indicated in a February 1988 letter to the AUC administration that his post from 1956-1957 was "the most interesting and satisfying position he had ever held."

When the British and French invaded Egypt in late 1956 triggering the Suez War, the Harvills and other AUC staff were evacuated in November to Geneva, Switzerland. Mrs. Harvill toured Europe for two months while furloughed with other AUC staff and spouses. She also toured Rome for several days, took a brief teaching position in an American Girls School in Athens, Greece, and also worked in the U.S. Air Force library there (*Campus Caravan*, 1957). Shortly after the Suez War broke out, both of Dr. Harvill's parents suffered heart attacks, and he returned to Kentucky, but left again for Egypt in late December 1956 in time to teach the second semester.

The Harvills were reunited at AUC on April 4, 1957. Upon Mrs. Harvill's return from Athens, there was much local fanfare and the AUC newspaper, the *Campus Caravan*, published an article with captioned photograph (Fig. 2), detailing the event in which she was described as being the first staff spouse to return to AUC following the military aggression in Egypt.

The Harvills returned to Kentucky so Dr. Harvill could teach at Murray State College from 1957 to 1961

Fig. 2. Barbara Jean Harvill and Alton M. Harvill, Jr. on the campus of the American University in Cairo, Egypt on the day of her furlough return on April 4, 1957 from Athens, Greece, following the Suez War evacuation in Egypt in November of 1956. Republished here by permission of Stephen Urgola, University Archivist, AUC from the AUC *Campus Caravan* newspaper, April 1957.

and be close to his convalescing parents. Through his connections at Murray State, Dr. Harvill spent the summer of 1962 at Oxford University and in July 1962 was awarded a NATO Advanced Study Institute grant, "North Atlantic Biota and Their History" to study in Reykjavik, Iceland. The Cuban Missile Crisis cancelled that opportunity and in December 1962, Dr. Harvill accepted a research position with the U.S. Geological Survey (USGS) in Washington, DC to conduct vegetation studies for the National Intelligence Survey (NIS).

The people and ideas to which Dr. Harvill was exposed at the NIS during 1962 had a profound influence on his future career direction and research interests. Dr. Harvill attributed his career-long interest in phytogeography to Dr. Henry K. Svenson, who was employed as a botanist by USGS until his retirement in 1966[4]. Dr. Harvill frequently referred to his experiences with Dr. Svenson in conversations, and cited Svenson's work and plant collections (particularly of eastern Virginia) as critical for modern vegetation interpretation (Harvill, 1973, 1984). Feeling considerable gratitude for his earlier training at the USGS in Washington, Dr. Harvill dedicated the *Atlas of the Virginia Flora, Second Edition* (Harvill et al., 1986) to his long-time mentor, Henry K. Svenson, "who started it all".

Military uncertainties and frequent travel led Dr. Harvill once again to return to teaching. In the fall of 1963, he accepted a professorship at Longwood College (now Longwood University, LU) where he taught numerous undergraduate courses in natural sciences, mentored students, and conducted personal research. During his tenure at LU, Dr. Harvill began to concentrate on vascular plants instead of bryophytes, and in 1965, he became involved with the Virginia Academy of Science (VAS) and the Virginia Flora Committee (VFC). However, when Dr. Harvill arrived at LU, the VAS had no direct "botany-focused" group within the Virginia Academy of Science (VAS) Biology Section. The idea of a separate and autonomous VAS Botany section was first discussed in May 1966 at the annual VAS meeting at James Madison College (now JMU, Harrisonburg, VA) (Morrow, 1970).

Dr. Harvill's commitment to this new section yielded a rapid and fundamental change in the direction and accelerated pace of floristic studies in Virginia

[4] Henry K. Svenson was a student of Dr. Merritt Fernald at Harvard University, and worked at the USGS from 1954 to 1966; see Wordpress.com's CCMNH Blog website, http://ccmnh.wordpress.com/2010/02/07/insect-catching-plants-particularly-of-cape-cod-by-dr-henry-k-svenson/.

botany, as he and others in the VAS re-energized previous efforts, initiated on February 16, 1926 by Virginia Polytechnic Institute and State University (VPISU) Professor A. B. Massey, to complete a state flora manual for Virginia (Lewis, 1934; Staggers, 1968: 66).[5]

In 1967, VPISU Biology Department Chairman Robert A. Patterson became very interested in Dr. Harvill's project focus, and tried to relocate him from Longwood to VPISU to facilitate the stalled state flora manual project, as Professor Massey had retired in 1959 (Roane, 1981, 1992). This effort was unsuccessful primarily because of Dr. Harvill's overriding interest in the Coastal Plain habitats, which were more easily reached from Farmville, Virginia.

Dr. Harvill's research effort increased, and dissemination of findings became important. He is believed to have been responsible for the 1967 founding of VAS's *Newsletter of the Flora Committee of the Virginia Academy of Science*,[6] which at that time was the primary medium for dissemination of botanical news pertinent to Virginia. Dr. Harvill served as editor for volumes 1 and 2 of this new publication in 1967 and 1968. He served as a member of the VFC from 1967 to 1973 and from 1969-1971, he also served as its Chairman. Additionally, Dr. Harvill and Dr. Stewart Ware (College of William and Mary) were co-editors of *The Newsletter* for volumes 3 through 8 from 1969 until October 1974, when editorship was taken over by Professor Howard Smith (University of Richmond).

In December, 1968, the *Richmond Times Dispatch* published a feature article (Orndorff, 1968) heralding an enthusiastic revival of interest in Virginia botany and estimated that more than 3,000 species of vascular plants inhabited the state. Dr. Harvill was quoted as stating "the Virginia Flora Committee's efforts are serving as a lens of sorts, bringing to a focus both new and old talent in botany for particularly significant purposes." He also said "vegetation is not only our most important natural resource, but is renewable. It is necessary to understand the biological and physical conditions necessary for renewal. We need people who know what is important to conserve and how."

From 1964 through 1973, Dr. Harvill published two to six papers every year on flora and biogeography of various locales in Virginia in journals like *Rhodora*, *Castanea*, *Virginia Journal of Science*, and *Jeffersonia*, even as he wrote his book, the *Spring Flora of Virginia* (1970). Dr. Harvill served as Councilor to the VAS in 1970, and on May 7, 1970, he presented his findings on the significance of disjunct distribution patterns in Virginia at the first provisional VAS Botany Section meeting in Richmond, with Dr. Stewart Ware presiding as the Botany Section Chairman[7]. Dr. Harvill expanded the ideas in the 1970 VAS presentation into a paper published in *Castanea* in 1972. Dr. Harvill also gave an invited presentation on the "Flora of Virginia" to the Smithsonian Institution Botany seminar series in Washington, DC[8].

Dr. Harvill's substantial productivity and his service on the VFC led to his being elected a Fellow in the VAS in 1971, the same year in which the Botany Section was permanently established at the VAS (Flory, 1973).

THE ATLASES OF THE VIRGINIA FLORA

Major planning for the State Flora Manual took place at Lynchburg College on October 20, 1973 under VFC Chairman Dr. Gwynn W. Ramsey (Lynchburg College). At this meeting, the VFC formed the Virginia Flora Manual Subcommittee and elected Dr. Alton Harvill, Jr. as editor-in-chief, with Dr. Miles Johnson (Virginia Commonwealth University) and Dr. Edmund Berkeley (University of Virginia) as associate editors for planned publications. The concept for the proposed "Atlas of the Virginia Flora" was patterned after the *Atlas of the Flora of the Carolinas* (Radford et al., 1965). Detailed discussions were formalized at the VFC meeting held on November 2, 1974 at Piedmont Junior (now Community) College in Charlottesville, and research and writing responsibilities were assigned to VFC members and others. Funding was later approved by the VAS Council largely through the efforts of Dr. Perry Holt and Dr. Robert Patterson (VPISU)[9].

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[5] Following the circulation of a letter of interest to the VAS officers from Professor Massey, at the fourth annual meeting of the VAS at the University of Virginia, Professor Massey presented a paper calling for a plan for a complete flora for the State of Virginia. The VAS proffered a $50 grant to the Biology Section, and it commissioned the four-man Committee on the Botanic Division of the Biological Section to undertake the work. This group became what is known today as the Virginia Flora Committee (VFC) (Lewis, 1934; Massey et al., 1950: 67; Staggers, 1968; Roane, 1981, 1992).

[6] This publication was renamed the "*Newsletter of Virginia Botany*", then was shortened to "*The Newsletter*". Beginning with Volume 6 (1972), it was again renamed "*Jeffersonia, A Newsletter of Virginia Botany*" and thereafter to "*Jeffersonia*" in 1974.

[7] *The Newsletter* 4(2) (1970).

[8] *The Newsletter* 4(4): 38 (1970).

[9] As reported in the *Minutes of the Meeting of the VFC*, published in Jeffersonia 8(3): 12-13 (1974).

The finance plan called for the VAS (Publications Committee) and VPISU (Virginia Agricultural Research Station) to each fund one-half of the $3,500 budget, and for the two-phase report (monocots and dicots) to proceed through the publications committee of the VAS, with printing to be performed by the VPISU Press or the University of Virginia Press. A deadline of May 1, 1975 was established for preparation of the text sections to be entitled Introduction, Physiography, and Plant Communities. For various reasons, these efforts failed to materialize.

THE VIRGINIA BOTANICAL ASSOCIATES

The Virginia Botanical Associates, Inc. (VBA), an organization of mostly academic botanists, was formed by Dr. Harvill in late 1974 to assemble individuals with similar interests in Virginia's flora[10]. The VBA grew gradually as individuals (who demonstrated this interest through their field collections) were invited into the group.

Following Mrs. Harvill's untimely death in January 1988, Dr. Harvill established the Barbara J. Harvill Memorial Fund for Botanical Research (BJHMF) to provide small research grants to interested individuals without institutional support for advancing knowledge of botany. The VBA was formally recognized as a nonprofit charitable organization by the Internal Revenue Service on December 18, 1989 to administer the BJHMF and to carry out the mission of the VBA.

Dr. Harvill, in collaboration with his hand-picked VBA research colleagues Charles E. "Mo" Stevens and Dr. Donna M. E. Ware, published the *Atlas of the Virginia Flora, Part 1, Pteridophytes through Monocotyledons* (Harvill et al., 1977). Many years in the making, this work compiled all documented herbarium records for ferns, fern allies, and monocots amassed from Virginia by VBA members and others and from regional and national herbaria over a period of many years from the mid-1960s onward.

From 1979 to 1981, Dr. Harvill published two more papers: an important work incorporating more recent data on the distributional patterns of the southwest Virginia flora (Harvill, 1979), which was a sequel to previous publications (Harvill, 1969, 1973), and a brief report on two new *Juncus* species in Virginia (Harvill, 1981).

Dr. Harvill also re-focused much energy and attention on updating the monocot records, as well as formulating the basis for the second volume on the dicots, *Atlas of the Virginia Flora, Part II, Dicotyledons* (Harvill et al., 1981), coauthored with VBA members Ted Bradley and Charles Stevens. This document synthesized studies based on the examination of more than 300,000 specimens and incorporated new distributional data from additional state herbaria that had not been previously studied.

RETIREMENT YEARS

Dr. Harvill formally retired as Professor Emeritus at Longwood University in 1983. This event permitted him to focus solely on his studies of Virginia botany. He spent much of his first 17 years after retirement pursuing numerous phytogeographical interests, refining ideas, filing papers, filling in distributional maps, and corresponding with a staggering number of botanical researchers, authors, and colleagues from around the world (Fig. 3). In 1984, Dr. Harvill started collaborative work for the *Atlas of the Virginia Flora, Second Edition* (Harvill et al., 1986) and published an important phytogeographical article in *Sida* (Harvill, 1984).

Much of the *Atlas of the Virginia Flora Part II* work and his later publications, were made possible through grants from the Longwood Research Committee and the Longwood Foundation.

As a testimonial to his continued productivity, service, and publication accomplishments, Alton M. Harvill, Jr. received the Thomas Jefferson Medal for Outstanding Contributions to Natural Science from the Virginia Museum of Natural History Foundation in 1988. While recovering from a bout of Lyme disease, on May 17, 1991, Dr. Harvill presented a masterful synopsis of Virginia phytogeography as a keynote speaker at the Wintergreen Resort's Spring Wildflower

Fig. 3. Dr. Alton M. Harvill, Jr. working in the Harvill-Stevens Herbarium, Longwood University, May 1995. Photo by Gwynn W. Ramsey.

[10] http://www.vaplantatlas.org/index.php?do=about:virginia_botanical_associates.

Symposium. The presentation, entitled "Plant Geography of Virginia: The Last 25,000 Years", fully described the vegetational history of the late Pleistocene and Holocene epochs in only 30 minutes. This research, with input from VBA members and others, laid the foundation for his three short essays entitled "Behind the Remarkable Floristic Diversity in Virginia (Sketch of the Plant Geography)", "The Origin, History and Distribution of the 'Coastal Plain' Flora", and the "Epilogue" that appeared in *Atlas of the Virginia Flora, III* (Harvill et al., 1992). These papers, based on plant studies firmly rooted in herbarium holdings, synthesized the state of knowledge of Virginia floristics at that time.

Dr. Harvill remarked that he was "the king of all drudgery" being swamped with all the text and details of the *Atlas of the Virginia Flora, III* by day and at night toiling through the processing of large volumes of voucher specimens[11]. A 1993 article in the *Richmond Times Dispatch* stated that at 76 years of age, Dr. Harvill was putting in 50 or more hours a week in the LU herbarium, doing "something useful" (Orth, 1993). Dr. Harvill worked tirelessly for six years after retirement to reduce the backlog of specimens in his care. This effort resulted in an unsurpassed collection of approximately 75,000 herbarium specimens of Virginia material (with Charles E. Stevens) now at LU[12]. Field botanists, ecologists, and other scientists and students in Virginia and elsewhere are the beneficiaries of his very productive work in laying the groundwork for the ultimate production by later workers of a manual of the flora of Virginia (now well underway as the Flora of Virginia Project)[13].

Dr. Harvill was particularly fond of engaging colleagues in discussions about the importance of the valuable palynological work of A. J. Craig (1969) at Hack Pond in Augusta County, Virginia, and J. T. Hack's dynamic landscape equilibrium concept formulated upon geomorphological observations in the Shenandoah Valley of Virginia (Hack, 1973, 1975). Dr. Harvill was once made nearly speechless at an annual VBA board of directors meeting upon receiving a final report and publication (Kneller & Poteet, 1999) resulting from a BJHMF grant award for palynological research at Spring Pond in Augusta County, Virginia by Columbia University graduate research assistant Margaret Kneller[14], later calling the results of her work "thoroughly astonishing".

Dr. Harvill frequently remarked in conversations on how important the Southwestern and Midwestern plant migrations were to the Virginia flora. Researchers familiar with the Virginia flora were to expect "the next big thing" to occur in western Virginia".[15] Dr. Harvill was also frequently heard extolling Douglas Ogle's re-discovery of Lloyd Carr's station (Carr, 1965) of *Senecio millefolium* in The Cedars region of Lee County, Virginia after it was "taxonomically lost" to science. Mr. Ogle's re-establishment of this species (Ogle, 1991) was greatly appreciated by Dr. Harvill. Doug Ogle was a VBA member who contributed numerous plant records to the various *Atlases* between 1977 and 1995, and was a coauthor of the second and third editions.

In 2000, due to health problems, Dr. Harvill officially retired from oversight of the VBA, and passed responsibilities to Dr. Ted Bradley (president, George Mason University) and Dr. Donna M. E. Ware (vice-president, College of William and Mary), both of whom are now also retired from the VBA.

ENDOWMENTS

Dr. Harvill used his early career earnings to invest in the stock market, and later converted some of the accumulated funds into student scholarship endowments at AUC and LU. In March 1990, in appreciation of AUC's impact on his career, and as a memoriam following the death of his beloved wife, Dr. Harvill established the Alton M. and Barbara J. Harvill Scholarship Fund to support an American student seeking funding to study abroad at AUC regardless of major. The scholarship was established as a testament to the Harvills' great respect for the mission of AUC and its importance to Egypt and the Middle East.

To honor Dr. Harvill, LU established the Alton Harvill, Jr. Scholarship in 1998. Administrated through the Admissions Office, this renewable annual scholarship is offered to an incoming LU freshman Biology major, and is based on academic merit.[16] More recently, a group of anonymous donors calling themselves the "Friends of the Harvills" established a

[11] Personal correspondence to the author dated August 29, 1991.

[12] http://www.longwood.edu/news/newsline/mar08/faculty.htm.

[13] http://www.floraofvirginia.org.

[14] Dr. Kneller, a paleoecologist, is now a lecturer at the John Cabot University, Rome, Italy.

[15] This prediction came to fruition with the publication of "The flora of dolomite and limestone barrens in southwest Virginia" (Ludwig, 1999), among others.

[16] http://www.longwood.edu/Sciences/biolscholarships.htm.

funded endowment in honor of Alton and Barbara Harvill to honor their "incalculable contribution to our scientific knowledge of Virginia's flora"[17]. This fund is used by the VAS Botany Section to select a winner(s) from among student papers presented to the Botany Section at annual VAS meetings, with preference given to graduate students reporting on research in plant taxonomy.

IN MEMORIAM

When Alton Harvill, Jr. passed away in 2008, Virginia lost a phytogeographic mastermind. Moreover, an era in botanical research came to a new beginning. In his career, Dr. Harvill published a total of 46 journal or newsletter articles (41 on vascular plants, five on bryophytes), three book reviews, and five books. The list of Dr. Harvill's publications is presented as Appendix 1.

Dr. Harvill was adept in bolstering confidence in young biologists who were fortunate enough to come under his influence. He was equally able to encourage those with difficult research and professional problems and was quick to help out those who needed assistance. Those who knew him held his friendship in high esteem and are better individuals and better scientists as a result of their relationship with him. The members of the Virginia Botanical Associates and much of the regional botanical community will forever cherish Alton McCaleb Harvill, Jr. in our hearts. We miss him.

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APPENDIX 1. List of Publications by Alton M. Harvill, Jr. (Compiled by Thomas F. Wieboldt and Robert Wright).

Harvill, A. M., Jr. 1947. Notes on the moss flora of Alaska: I. The mosses of Attu Island collected by Margaret Bell Howard and George B. Schaack. The Bryologist 50: 169-177.

Harvill, A. M, Jr. 1947. Notes on the moss flora of Alaska: II. Mosses of the Mount McKinley region. The Bryologist 50: 341-347.

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Harvill, A. M., Jr. 1950. *Diphyscium cumberlandianum*, a pre-Pliocene relic with Paleotropical affinities. The Bryologist 53: 277-282.

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Miscellanea

Reviews

Natural History of Delmarva Dragonflies and Damselflies: Essays of a Lifelong Observer by Hal White. 2011. University of Delaware Press (in collaboration with the Delaware Nature Society). 284 pp. Available for $30 from the University of Delaware Press, Delaware Nature Society, Amazon.com, etc.

The term "Delmarva Peninsula" (or simply Delmarva) refers to the region between the Atlantic Ocean/Delaware Bay and Chesapeake Bay that includes the state of Delaware and the Eastern Shore portions of Maryland and Virginia (9 and 2 counties, respectively). In the past two decades, The Delaware Nature Society has collaborated with regional publishers to produce several guides to the biota of Delmarva, including butterflies (Woodbury, 1994; see review by Roble, 1995) and amphibians and reptiles (White & White, 2002; see review by Roble, 2004), and now dragonflies and damselflies (Order Odonata). Compared to the earlier books, this one is of a larger format (6" x 9") and has a sturdier binding, with a flexible hardcover.

This book treats 131 species, including 87 dragonflies and 44 damselflies, the first such summary of the entire Delmarva fauna. Three of these species have not been confirmed on the Delmarva Peninsula, although *Ophiogomphus incurvatus* is included based on probable sight records made by the author. Another species (*Somatochlora georgiana*) was first documented on Delmarva when the book was nearing publication, so it was added at the end of the species accounts out of taxonomic order. All but two of the species treated in the book have been documented somewhere in Virginia, and one of the others (*Tramea calverti*) likely visits coastal areas of the state occasionally. Thus, about two-thirds of Virginia's Odonata fauna (191 species) is discussed in the book. However, only 47 species (30 dragonflies and 17 damselflies) have been found in the two counties comprising Virginia's Eastern Shore, with 24 recorded from Northampton County and 38 from Accomack County (based on data provided by me to the author). More intensive sampling might yield as many as 25 additional species for the Virginia portion of the Peninsula, but I doubt if the total exceeds 75 species. As is true of freshwater fish, amphibians, and reptiles (Jenkins & Burkhead, 1994; Mitchell, 2002; White & White, 2002), species diversity of Odonata declines significantly from north to south on the Delmarva Peninsula. On Virginia's Eastern Shore, the diversity of dragonflies and damselflies is quite low compared to the mainland portion of the state due to several factors, including the rather limited number of natural freshwater habitats (vs. farm ponds, mill ponds, etc.), the inability of most species to tolerate habitats that are affected by saltwater intrusion or salt spray, the presence of few free-flowing streams, the virtual absence of rivers, and historical habitat alteration (e.g., draining and loss of essentially all Delmarva bays on Virginia's Eastern Shore for agricultural purposes).

Hal White is a biochemist who has been on the faculty of the University of Delaware for the past four decades. His passion for the study of Odonata as a hobby spans more than half a century and includes several publications on regional faunas (e.g., White et al., 1968; White, 1989; Shiffer & White, 1995) and larval descriptions for two rare dragonflies. When writing this book, he deliberately chose to take a different approach than the traditional one used in other recent regional guides to Odonata (e.g., Lam, 2004; Beaton, 2007). Rather than have the book read more like a typical field guide, he prepared many natural history essays (one per species) plus brief species descriptions and life history summaries. A small range map (with the counties of occurrence shaded) appears on the first page of each species account. One or more color photos ranging from large to small (too small in some cases) and excellent to fair are provided for each species. The book concludes with four appendices, including a list of species (n = 19) that might occur on Delmarva, historical records of species that have not been found recently on the Peninsula, and descriptions of Odonata habitats in the region. The final appendix consists of a table summarizing the county distribution and flight dates of all species (*Argia sedula* omitted) on the Peninsula. This attractive book is well edited and I noted only a few very minor typographical errors.

The natural history essays and associated species accounts comprise the bulk of the book, which is easy and enjoyable to read. The essays are well written and cover a broad range of topics, including historical figures in entomology, behavior, physiology, voucher specimens, taxonomy, common names, life cycles, sexual dimorphism, anatomy, ecology, predators, and conservation. Several narratives discuss events related to the discovery (or rediscovery) of particular species on Delmarva. The author frequently expresses his concerns related to the long-term future and conservation of the Peninsula's Odonata fauna in the face of an expanding human population, increased urbanization, and the ever-increasing disconnect between nature and society, perhaps fearing that only a few generalist, pollution-tolerant species will still be

present a century or more from now.

This is a nice addition to the literature on regional natural history and should be read by all naturalists regardless of the level of their interest in Odonata.

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Steve Roble
Editor, *Banisteria*

Reports

1. President's Report

Human activity is affecting natural selection processes and evolution. We have contributed to increased carbon dioxide levels in the air and in the oceans which in turn have increased the acidity of ocean water so much so that reef building corals are affected deleteriously. We make and use agricultural chemicals such as pesticides that affect insects, fungi, nematodes and bacteria and we change whole soil ecosystems. We move organisms around so easily that many have become exotic invasives which may outcompete native species. We artificially select domestic animals and plants for special traits that might not make them evolutionarily "fit" in a natural environment. We currently have antibiotic resistant populations of bacteria, plants that contain genes from other species and we have artificially selected dogs that range in size from miniature to gigantic. These changes were effected in just a few years, not the thousands or millions that natural selection might take. Oh, and there is a species extinction going on at a rate to rival that of some of the past mass extinctions. All of these are good reasons to submit your Virginia **NATURAL** history manuscripts for publication in *Banisteria*.

In December 2011 the Executive Committee of the Virginia Natural History Society met at Hampden-Sydney College. There were favorable reports given that membership had increased, new issues of *Banisteria* were well on their way to completion, and that the Society's financial assets were adequate. We look forward to a prosperous year in 2012. Please make an effort to enlist one new member this year.

Respectfully submitted
Ralph Eckerlin, President
Virginia Natural History Society

2. Secretary-Treasurer's Report

As of December 3, 2011, the society has 117 members, including 19 institutions. This represents an increase in membership from December 2010 (105 members, 17 institutions). In December 2009, we had 122 members, including 19 institutions. Membership has declined over the past five years from the most recent high point in 2004, when we enrolled 165 members, including 22 institutions. This is an approximate 29% decline to the current number. The slight increase this year (12 members) inspires hope that the decline may be reversing.

Our current bank balance is $9,360.66, up $2,178.04 from one year ago.

Respectfully submitted,
William A. Shear, Secretary/Treasurer

3. Webmaster's Report

VNHS website traffic during the past five months is summarized in the following table:

Month	Page Loads	Unique Visitors	First Time Visitors	Returning Visitors
Jul 2011	59	55	2	53
Aug 2011	63	50	38	12
Sep 2011	202	178	92	86
Oct 2011	238	216	133	83
Nov 2011	209	191	94	97

DEFINITIONS:
Page Loads - The number of times the VNHS front page was visited.
Unique Visitors - Total number of visitors (first time plus returning).
First Time Visitors - First time visitor to the VNHS website.
Returning Visitors - A person returning to our website for another visit an hour or more later.

Location of recent VNHS visitors:

On or about August 5, 2011, the Conservation Management Institute (CMI) removed the VNHS website from their servers without prior notice. On August 8, the VNHS website was uploaded to the new CMI website. Unfortunately, as a result of the website removal (for the second time in the past two years), Google software detected our absence and automatically removed all references and links to the VNHS website from their search engine. In an effort to avoid similar events in the future, the VNHS has decided to move its website to a commercial web-hosting service. We would like to thank CMI for hosting the VNHS website since its inception more than a decade ago. Our new website should be up and running in early 2012 at the following address: **http://virginianaturalhistorysociety.com/**

Respectfully submitted,
John White, Webmaster

4. Editor's Report

This is the second issue of *Banisteria* that I have produced within the past two months, the first being about five months late. At more than 100 pages, this is the second largest issue in the 20 year history of *Banisteria*. Based on the number of recent submissions that were not ready for inclusion in this issue when it went to press, as well as other papers that are in preparation and known to me, it is likely that one or both of next year's issues also will be rather substantial. In an effort to increase the journal's readership, I encourage everyone to recruit at least one new (or former) member to the society in 2012 (see inside back cover for membership application form).

Please consult the new VNHS website for the revised instructions for authors before submitting a manuscript. Note that page charges are waived only if the sole or first author is a member of VNHS; otherwise the fee is $20 per journal page (an increase from $15). Society members with grant funds are encouraged to contribute toward printing costs. Student rates for membership remain at the bargain price of $5 per year, so student authors (as well as other students) are strongly encouraged to join the society. All authors must pay $75 per page for color printing (an increase from $50, which better reflects the actual cost).

I would like to thank the following people for reviewing manuscripts submitted to *Banisteria* during the past two years (* = reviewed more than one paper): Steve Adams, Paul Bedell*, Art Bogan*, Richard Brown, Steve Bullington, Roger Clapp, Charlie Covell, Bob Davidson*, Andy Deans, Mark Deyrup, Terry Erwin, Art Evans*, Ollie Flint, Karen Francl, Carola Haas, Tom Henry*, Kevin Hinson, Rick Hoebeke, Richard Hoffman*, Clyde Kessler, Boris Kondratieff, Steve Lingafelter, Svetlana Maslakova, John McDermott, Jay McPherson, Joe Mitchell*, Al Newton, Jon Norenburg*, Jane O'Donnell, Brett Ostby, John Pagels, Tom Pauley, Norm Platnick, Jerry Powell, Bob Rose*, Don Schwab*, Bill Shear, Dick Smith, Charlie Staines, Warren Steiner*, Mike Thomas, Johnny Townsend, Donna Ware, Stewart Ware, Brian Watson*, Al Wheeler*, Tom Wieboldt*, and J.D. Willson. I apologize if I forgot to include any other reviewers.

Finally, I would like to thank founding co-editor and current associate editor Richard Hoffman for his continued advice and encouragement related to this journal, and Precision Print & Copy, a family-owned business in Richmond, for their excellent work in producing this and the previous 12 issues of *Banisteria*.

Respectfully submitted,
Steve Roble, Editor, *Banisteria*

Announcements

1. Membership Renewals

A membership renewal notice for *Banisteria* numbers 39 and 40 (2012) is enclosed with this issue. Please return the form and dues to Dr. William A. Shear, Secretary/Treasurer, Virginia Natural History Society, Box 96, Hampden-Sydney College, Hampden-Sydney, VA 23943.

2. New Frog and Toad Brochure

The Virginia Department of Game and Inland Fisheries has produced a 44 page guide to the 27 species of frogs and toads native to Virginia. Identification, biology, behavior, habitats, and conservation issues are discussed for each species. The guide is illustrated with more than 80 color photographs and line drawings and includes a complimentary CD entitled *The Calls of Virginia Frogs and Toads*. It can be purchased for $10 from the VDGIF on-line gift shop: https://www3.dgif.virginia.gov/estore/proddetail.asp?prod=VW256. Copies of *A Guide to the Snakes of Virginia* (published in 1995) are still available for $5.

3. Two New Vascular Plant Species in Virginia

A paper entitled "A New *Phemeranthus* (Portulacaceae) from the Piedmont of Virginia and North Carolina" by Stewart Ware of the College of William and Mary was recently published in the *Journal of the Botanical Research Institute of Texas*. This new plant species was co-discovered by Chris Ludwig, chief biologist for the Virginia Department of Conservation and Recreation, Division of Natural Heritage (DCR-DNH), and University of North Carolina-Chapel Hill botanist Alan Weakley at separate locations in Virginia and North Carolina in the 1990s. The paper formally describes this new species of the purslane family as *Phemeranthus piedmontanus* (Piedmont Fameflower). It is known from only a handful of rock outcrops in the two-state area, including DCR-DNH's Grassy Hill Natural Area Preserve in Franklin County.

A second new species of vascular plant was described by DCR-DNH ecologist Gary Fleming, DCR-DNH botanist Johnny Townsend, and University of South Carolina botanist John Nelson in another paper appearing in the same journal entitled "A new hedge-nettle (*Stachys*: Lamiaceae) from the mid-Atlantic Piedmont and Coastal Plain of the United States." A member of the mint family, *Stachys matthewsii* (Matthews' Hedge-nettle) is endemic to the Piedmont of southern Virginia and North Carolina, as well as an area along the James River in Surry County, Virginia. The paper is the culmination of more than 30 years of research conducted by the authors, both individually and collectively. A number of historical collections of this new species had been made between 1938 and 1978 but the specimens were incorrectly attributed to other species. Between 1978 and 1998, the authors discovered additional populations of this plant and recognized that it represented an undescribed species. Matthews hedge-nettle is named in honor of James Matthews, an outstanding botanist, teacher, and mentor at the University of North Carolina-Charlotte.

4. Bringing the Flora Home

There is still time to receive a complimentary copy of the *Flora of Virginia.* If you make a gift of $1,000 or more to the Flora of Virginia Project by May 1, 2012, you will receive a copy of the first edition in recognition of your gift, with your name listed at your giving level. The manual will be published in the fall of 2012, exactly 250 years after our only other flora, 1762's *Flora Virginica.*

You can also pre-order copies of *Flora of Virginia*. To do so, please visit the website of the *Flora's* publisher, the Botanical Research Institute of Texas Press, at http://brit.org/brit-press/books/virginia, or send your payment ($79.95 + $6.50 shipping) to BRIT Press, 1700 University Drive, Fort Worth, Texas 76107-3400. You will receive your copy of *Flora of Virginia* upon publication.

The authors of *Flora of Virginia* are Alan Weakley, curator of the University of North Carolina Herbarium and an adjunct professor at UNC-Chapel Hill, Chris Ludwig, chief biologist for the Virginia Department of Conservation and Recreation, Division of Natural Heritage (DCR-DNH), and Johnny Townsend, staff botanist for DCR-DNH. At this stage, the authors' attention is turned to editing, writing a few remaining keys, and preparing for a March 2012 due date at the publisher.

In its 1,500 pages, *Flora of Virginia* will present descriptions of some 3,200 taxa that are native to or naturalized in the state, with 1,400 pen-and-ink illustrations commissioned for the work. It also will feature keys, a chapter on the nature of the Virginia flora, and another on the history of botanical exploration in the state.

For more information on the Flora Project, please visit floraofvirginia.org.

Virginia Natural History Society

http://virginianaturalhistorysociety.com/

General Information

The Virginia Natural History Society (VNHS) was formed in 1992 to bring together persons interested in the natural history of the Commonwealth of Virginia. The VNHS defines natural history in a broad sense, from the study of plants, animals, and other organisms to the geology and ecology of the state, to the natural history of the native people who inhabit it. The goals of the VNHS are to promote research on the natural history of Virginia, educate the citizens of the Commonwealth on natural history topics, and to encourage the conservation of natural resources.

Dissemination of natural history information occurs through publication of the journal *Banisteria*, named for John Banister (1650-1692) who was the first university-trained naturalist to work in Virginia. The first issue was published in 1992, and the journal is published twice per year in spring and fall. Articles cover a wide array of subjects, and prospective authors are encouraged to submit manuscripts on any aspect of natural history in Virginia; papers may pertain to Virginia or regional archaeology, anthropology, botany, ecology, zoology, paleontology, geology, geography, or climatology. Book reviews, biographies, obituaries, and historical accounts of relevance to natural history in Virginia also are welcomed. Manuscripts are peer-reviewed for suitability and edited for inclusion in the journal.

Page charges ($20/page) are waived if the sole or first author is a VNHS member. All authors must pay $75/page if they desire color printing of figures. The society's website contains detailed instructions for authors and the titles, abstracts or full PDF versions of articles from past *Banisteria* issues.

Memberships

The VNHS is open to anyone with an interest in natural history and welcomes participation by all members in society activities and efforts to promote education and conservation. Membership includes a subscription to *Banisteria* and invitations to periodic symposia and field events. Annual dues for members are $20 (per calendar year); library subscriptions are $40 per year. Checks should be sent to the Secretary/Treasurer, who also has back issues of *Banisteria* available at $10.00 each (except Nos. 1-6 are $5.00 and No. 13 is $18.00). The VNHS is a tax-exempt, nonprofit, society under Section 501(C)3 of the IRS. We welcome donations to support our mission in Virginia.

Virginia Natural History Society

Application for Membership

Name _____

Address_____

_____

_____

Zip Code _____

Phone _____

Email _____

Area(s) of Interest _____

ANNUAL DUES AND SUBSCRIPTIONS TO *BANISTERIA*

(memberships and subscriptions are by calendar year; subscribers/members outside the United States should add $3.00 for additional postage)

- ☐ $500.00 Life (not annual)
- ☐ $300.00 Benefactor
- ☐ $100.00 Patron
- ☐ $50.00 Supporting
- ☐ $40.00 Institutional
- ☐ $25.00 Family
- ☐ $20.00 Regular
- ☐ $5.00 Student (see below)

☐ I have added a contribution of $_____ to my membership dues.

The special student rate is applicable only when accompanied by the following certification signed by a faculty advisor.

Institution _____

Advisor _____

Date_____

Make checks or money orders payable to:
Virginia Natural History Society

Send membership form and dues to:
Dr. William Shear, Secretary-Treasurer
Virginia Natural History Society
Box 96
Hampden-Sydney, VA 23943

Dismal Swamp Southern Bog Lemming
(*Synaptomys cooperi helaletes*)

This small rodent was described from the Dismal Swamp more than a century ago and later thought to possibly be extinct. Recent surveys reveal that this disjunct subspecies is widely distributed in southeastern Virginia as discussed on pages 60-64 of this issue.